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Technology Review

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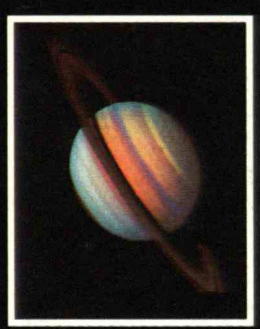
An intact Saturn 5, which cost the American public $200 million, sits rusting in Houston,

a vivid testimonial to what we used to be able to do in space.



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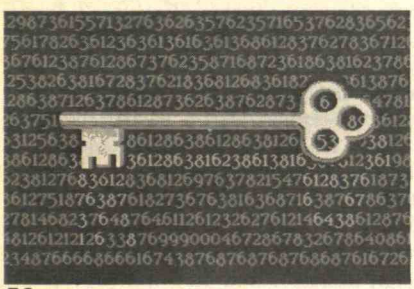
30



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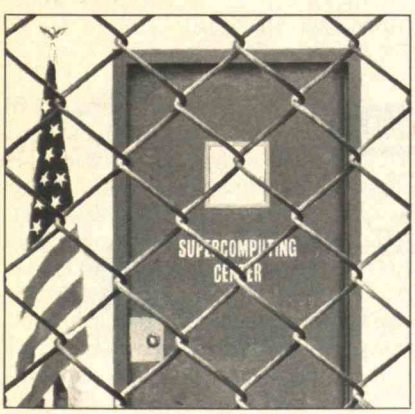

68

COVER
Photos: NASA
Design: Kathleen Sayre

The Issues in Space

Two contributions to this issue bear on the future of NASA and the U.S. space program following the loss of *Challenger*. Robert C. Cowen stresses the extent of national commitment that will be required if the recommendations of the National Commission on Space chaired by Thomas O. Paine, former NASA administrator, are to be fulfilled. Ruth and John Lewis make the same point regarding a future space program somewhat different from that recommended by the Paine commission.

The Paine commission's highly promotional report, which included mellifluous promotions of first a "highway to space" and then a "bridge between worlds," was clouded by its timing. The deliberations took place before the loss of *Challenger*, but publication was possible only after that accident. Even so, the report raises intriguing prospects—a program with the long-term goals that both the Lewises and Cowen say NASA lacked. U.S. investments in space would double by 1995, and there would be continuing increases at roughly the rate of projected growth of G.N.P.—about 2.5 percent a year.

But to the *Review*'s editors, the more interesting questions are those that extrapolate from the agenda of the Rogers commission investigating the *Challenger* disaster: how shall we maintain the vigor, integrity, professionalism, and consensus that will increasingly be required as our enterprises in space become more costly, more complex, and less forgiving of human error?—*John Mattill*

NSPE AWARD

We announce with pride the selection of "Construction's High-Technology Revolution" by Fred Moavenzadeh (*October 1985, pages 32-41*) for first place in the "general-interest magazine" category of the 20th annual journalism awards by the National Society of Professional Engineers. Moavenzadeh's article cited new opportunities in automation, materials, and management that give the U.S. construction industry important leverage over increasingly aggressive competition from other nations.

MERIT FOR DESIGN

Eight entries from *Technology Review* were accepted by the jury for the 1986 exhibition of the Art Directors Club of Boston late last spring. They include our August/September 1985 cover on avoiding accidental war and that of January 1986 on artificial intelligence; editorial illustrations by Stephen Elston, Geoffrey Moss, Anthony Russo, and Michael Young; and the design for the article "Our Restive Beaches" (*April 1985*). While we happily share these kudos with our illustrators, we claim a major role for Nancy Cahners, design director, and Kathleen Sayre, design and production manager.

The Politics of "Yellow Rain"

"YELLOW RAIN": CHEMICAL WARFARE?

In "One Scientist's Crusade," Alison Bass goes to great lengths to promote Matthew Meselson's views on biological and chemical warfare (*April, page 42*). She also tries to discredit those who question his statements and his motivations. But there are many legitimate challenges to the contention that Soviet-supported military groups are not using chemical weapons in the Third World. There are also some questions about Meselson's methodology and objectivity.

The greatest problem is his ethnocentric dismissal of eyewitness testimony by members of Laotian, Cambodian, and Thai tribes. It is bad science to assume that people who are not white and educated in the West cannot give reliable information.

A second problem is that Meselson tends to narrow the scope of his research to suit his hypothesis. Since the underlying issue is the use of chemical weapons in the Third World, he should consider more than just yellow spots on leaves.

Afghan freedom fighters and civilians have been attacked with chemical weapons. In one case Afghan fighters killed a Soviet soldier dressed in a chemical-protection suit. His headgear and respirator were handed over to the West. In another case a French journalist photographed a helicopter dispersing a yellow cloud over a small village. The journalist left the site and returned later that day to find inhabitants of the village writhing in the streets. In both of these cases objective evidence exists—as does eyewitness testimony by a white Westerner.

ROBERT DEZMELYK
Cambridge, Mass.

The author responds:

Many anthropologists, physicians, and sociologists specializing in Southeast Asian culture agree with Meselson that the refugee tales of yellow rain are not persuasive evidence of chemical and biological warfare in Southeast Asia. These experts note that almost all the refugee interviews were done in camps where Laotian tribespeople had been selected in advance because they said they had experienced or witnessed chemical attacks. Randomly chosen refugees from the same villages might have provided cross-checks, but such refugees were not sought out. Both the refugees and their interpreters were aware that the purpose of the interviews was to gather information about chemical warfare, and no efforts were made to ensure that the refugees did not try to accommodate their responses to the expectations of Western investigators.

Furthermore, as both Meselson and *Chemical and Engineering News* have pointed out, the highland people of Vietnam reported widespread death and illness similar to that associated with yellow rain. Yet the Vietnamese were exposed only to herbicides used by the United States during the Vietnam War, and these chemicals do not cause immediate death or illness.

Alison Bass's article on scientist/activist Matthew Meselson is a fine piece of writing. The subject hits home for those of us who wonder whether we will ever find a moral purpose for our expertise. Thanks for giving us something to think about.

RICHARD L. MEEHAN
Stanford, Calif.

Richard Meehan is adjunct professor in Stanford University's Program in Values, Technology, Science, and Society.

PROFESSIONALISM IN ENGINEERING

I agree with Samuel Florman that the liberal-arts curricula for today's undergraduate engineering students are inadequate (*"Toward Liberal Learning for Engineers," February/March, page 18*). But I think the solution he proposes is not radical enough.

My own solution would be to require post-baccalaureate professional engineering degrees. Undergraduates could pursue engineering science as a major, but their degree would in no way confer professional status. Professional engineering schools would offer two additional degrees—an engineer's degree and an academic doctorate, just as medical schools offer an M.D. and a Ph.D. The engineer's degree program would be three years long. Two of these years would be spent on the traditional engineering disciplines, and the student would choose an area of specialization. The third year would be an industrial internship. Such cooperation between industry and the university would have many attractive features: practical experience for the student, exposure of academics to current technological problems, and industry involvement in the training of new professionals.

Currently, most "engineers" are not.

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The profession needs to be more clearly defined so that control of the engineering enterprise may return to actual engineers. Society can ill afford the catastrophes that can occur when management decisions override engineering judgments.

V. P. MANNO
Medford, Mass.

V.P. Manno is assistant professor of mechanical engineering at Tufts University.

SUBSTITUTES FOR METALS FROM SOUTH AFRICA?

I was disturbed by Lance Antrim's suggestion that the United States should find substitutes for strategic metals from South Africa (*Letters, January, page 2*). The Republic of South Africa is known to be friendly to the West, and it needs the support of the West. Furthermore, no one has ever found acceptable substitutes for the metals in question.

L. KIOILOS
Bedfordview, South Africa

ABORTION CONTROVERSY

Nancy Rhoden makes an interesting point in asking the Supreme Court to uphold the spirit of the *Roe v. Wade* decision rather than the letter of the law. However, it was not the spirit of *Roe* to provide abortion as an alternative to contraception and develop the procedure into a multibillion-dollar industry. If the spirit of the law were indeed upheld, there would still be concern for unborn human life.

PATRICK J. DeLUCA
Newburgh, N.Y.

TRAINS ON ICE

I enjoyed Louis Thompson's "High-Speed Rail" (*April, page 32*). But I was disappointed that he did not discuss the possibility of putting a high-speed railroad totally underground, which would eliminate many problems. Land acquisition for rights of way would be unnecessary, as would bridges, earth fill, and other expensive efforts to minimize curves and grades. Trains would not interfere with road traffic, cause noise pollution, or endanger cattle, human beings, and automobiles. Also, there would be no stresses and buckling forces on the track from temperature variations and frost, and the rails could be laid absolutely straight, reducing wear.

New technology could be used, too. For example, instead of steel wheels on steel rails, trains could use skates or skis in troughs of ice. Skates or skis could weigh only a tiny fraction as much as wheels and bearings. This would reduce the wear from high-speed travel enormously. And the track could periodically be leveled very precisely by melting and re-freezing during night-time shutdown.

Finally, the atmospheric pressure of the tunnels could be controlled to remove wind resistance. Passengers would have to enter and exit pressurized cars through thoroughly reliable air locks, but our space program has shown that those air locks can be made.

Of course, passengers would not tolerate an acceleration rate much greater than that they experience on jets. Nevertheless, it would take only 3.5 minutes and 41.3 miles at such a rate to reach 1,400 miles an hour. This is, as I remember, the speed at which test sleds were driven along a track in the early days of our country's rocket-research program. Higher speeds should be possible in the manipulable environment of a tunnel.

Since "sled-trains" could travel so fast, they could make many trips per day, offsetting the high fixed cost of creating tunnels. The use of these trains could alleviate airline congestion as well.

JOHN M. BRADLEY
Manchester, Mass.

The idea of high-speed rail did not originate in foreign countries. As a matter of fact, several U.S. railroads used to operate at quite high speeds. In the 1960s I often rode the Illinois Central and clocked speeds of up to 120 mph.

The leadership of other countries in high-speed rail is due to three important factors. First, in other countries the track is less expensive to maintain because it is not shared with freight trains containing a high percentage of 100-ton cars. Second, political pressure to make stops at many small towns precludes high average speeds in the United States. Third, since U.S. railroads have so many grade crossings, high speeds are extremely hazardous to the motoring public.

ROWLAND PEAK
Metairie, La.

WHERE TO MAKE BUDGET CUTS

In "Calling the Gramm-Rudman Bluff" (*May/June, page 20*), Lester Thurow says that no one can balance the budget with-

Continued on page 54

Overcrowded classes. Where bigger isn't better.

Imagine trying to divide your time equally among 30 or 40 employees a day.

This is the daily dilemma teachers face in overcrowded classrooms. They must spend more time with the low achievers, extra time with the brightest students, leaving little time for the rest of the class.

In most schools, a student gets hours of daily instruction. But when a child needs special encouragement or one-on-one teaching, she or he is lucky to get ten minutes of individual attention a day.

Regardless of grade level or ability, students achieve more as class size is reduced. A student in a class of 40 will score 10 points lower on national tests than the same student would in a class of 20.

We've also seen that smaller classes decrease discipline problems. And they increase a student's self-esteem while also increasing a teacher's job satisfaction.

Reducing class size is a primary goal of the NEA. We know it is one of the surest ways of getting education back in the picture and on the track of excellence. And that is our goal.

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THE SUBJECT IS EXCELLENCE

Fiber optics: beyond 20,000,000,000 bits/sec.

Summary:

GTE scientists have demonstrated laser modulation and detection at rates as high as 20 gigabits/second. They have developed ultra-small lasers that have light emitting areas as small as 0.2 square microns. They are working to improve the glass fiber itself, as well as to produce optical analogs of electronic switches with the long-range goal of all-optical systems, in which message streams are switched as much as 10,000 times faster than at present.

GTE commercial involvement in fiber optics communications systems dates from the first such installation in Artesia, California, in 1977.

Our scientists developed the system's technology and equipment, and have been contributing to the state of the art ever since.

Current projects deal with increasing the capacity, the versatility, the applications of the systems; longer-term, we are exploring the possibility of all-optical systems.

Faster and faster...

Until recently, optical systems processed digital streams at speeds ranging up to hundreds of megabits per second.

Fast though that may seem, today's carriers are seeking speeds in the gigabits-per-second range. This might even permit the glass to be brought directly to satellite earth stations or microwave towers, for example, for direct conversion of radio signals to light.

Recently, GTE demonstrated the ability to turn diode lasers on and off at rates as high as 20 gigabits per second—about 333% higher than the greatest previously recorded speed.

...and smaller and smaller.

Such speeds require very special lasers. And, as you can see from the electron micrograph at upper right (the head of an ant looking at one of these lasers), it is extremely small.

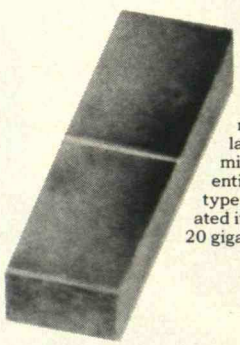
It was constructed on a wafer of InP, by epitaxial growth of a layer of InGaAsP approximately 0.1 micron thick. This was then etched to a mesa shape, and further layers of InP added.

The resulting laser cavity is approximately 0.2 square micron in area, and provides an excellent mate for single-mode glass fiber (fiber with a core of such small diameter that light travels a single path—mode—drastically lowering its dispersion within the fiber).

Switching light with light.

In another project, we are investigating the possibility of ultimately eliminating the electronics altogether by using optical switches.

We are working with materials whose indices of refraction vary with the intensity of incident light—a nonlinear response.

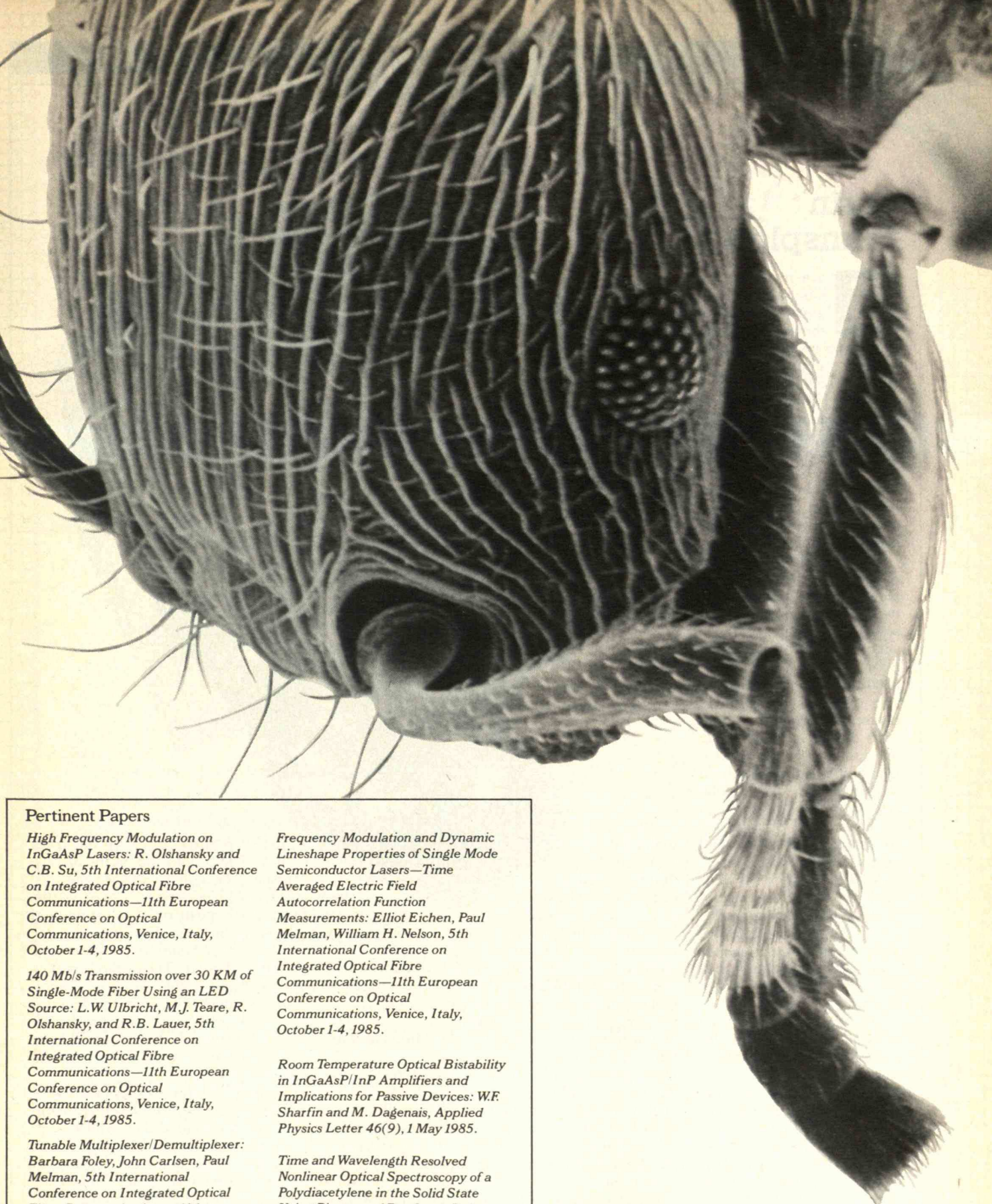


Head of an ant dwarfs a submicron-sized diode laser in this electron micrograph. GTE scientists developed this type laser, and have operated it at rates as high as 20 gigabits a second.

Ultimately, if it actually does become possible to switch systems optically, an improvement in speed of as much as 1,000,000% is theoretically possible.

In its brief history, fiber optics has made astonishing strides. At GTE, we are working to continue at the frontiers of this science—to make fiber optics an even more helpful technique to meet the endless needs of tomorrow's telecommunications.

The box lists some of the pertinent papers GTE people have published on various aspects of fiber optics. For any of these, you are invited to write GTE Marketing Services Center, Department FO, 70 Empire Drive, West Seneca, NY 14224. Or call 1-800-833-4000.



Pertinent Papers

High Frequency Modulation on InGaAsP Lasers: R. Olshansky and C.B. Su, 5th International Conference on Integrated Optical Fibre Communications—11th European Conference on Optical Communications, Venice, Italy, October 1-4, 1985.

140 Mb/s Transmission over 30 KM of Single-Mode Fiber Using an LED Source: L.W. Ulbricht, M.J. Teare, R. Olshansky, and R.B. Lauer, 5th International Conference on Integrated Optical Fibre Communications—11th European Conference on Optical Communications, Venice, Italy, October 1-4, 1985.

Tunable Multiplexer/Demultiplexer: Barbara Foley, John Carlsen, Paul Melman, 5th International Conference on Integrated Optical Fibre Communications—11th European Conference on Optical Communications, Venice, Italy, October 1-4, 1985.

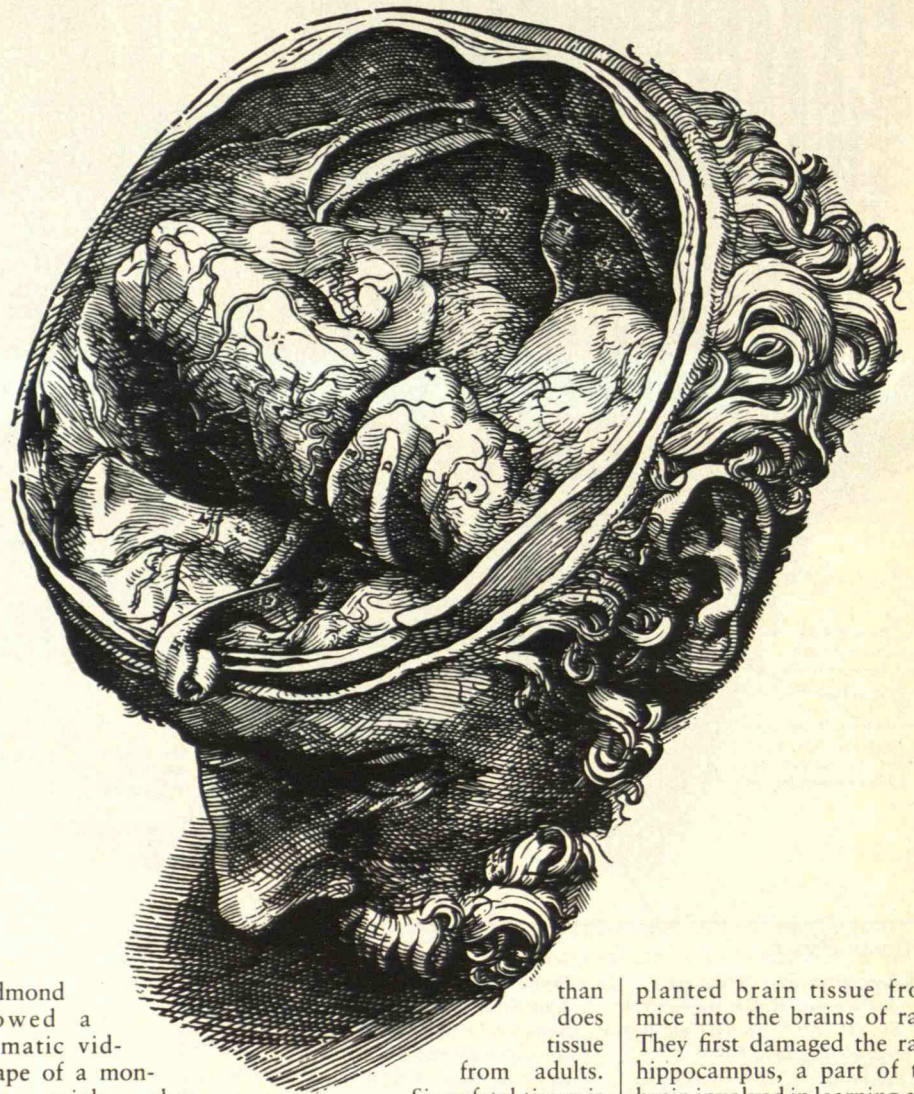
Frequency Modulation and Dynamic Lineshape Properties of Single Mode Semiconductor Lasers—Time Averaged Electric Field Autocorrelation Function Measurements: Elliot Eichen, Paul Melman, William H. Nelson, 5th International Conference on Integrated Optical Fibre Communications—11th European Conference on Optical Communications, Venice, Italy, October 1-4, 1985.

Room Temperature Optical Bistability in InGaAsP/InP Amplifiers and Implications for Passive Devices: W.F. Sharfin and M. Dagenais, Applied Physics Letter 46(9), 1 May 1985.

Time and Wavelength Resolved Nonlinear Optical Spectroscopy of a Polydiacetylene in the Solid State Using Picosecond Dye Laser Pulses: G.M. Carter, M.K. Thakur, Y.J. Chen and J.V. Hryniewicz, Applied Physics Letter 46(9), 1 May 1985.

GTE

Brain Transplants



Even in this era of almost-routine organ transplants, the idea of brain transplants invokes images of Frankenstein's laboratory and mad scientists tampering with the human soul. The brain is one organ that would seem to be beyond manipulation. However, recent studies demonstrate that transplanting pieces of healthy brain into a diseased one could help alleviate some neurological diseases.

At the Society of Neurosciences annual meeting in Dallas in November 1985, two separate groups of researchers presented data on successful implantations. Both studies used transplanted animal fetal brain tissue to treat chemically induced symptoms of Parkinson's disease in monkeys. In one group, Donald E. Redmond and Robert Roth of Yale collaborated with John Sladek at the University of Rochester. The other group consisted of Roy Bakay and others at Emory University.

Parkinson's disease is characterized by the destruction of the substantia nigra. This part of the brain produces dopamine, one of the neurochemical messengers that transmits information between areas of the brain.

The implants came from areas of the brain rich in dopamine. When these implants were placed into the area of the brain where dopamine levels decrease in Parkinson's disease, they apparently took root in the "diseased" brain and produced enough dopamine to counteract the effects of the toxins. Both teams reported that the animals' condition soon improved markedly.

Redmond showed a dramatic videotape of a monkey with the Parkinson symptoms of rigidity and slow movement. Two weeks after receiving the implants, the monkey moved freely about its cage, easily grasping food and feeding itself, looking healthy. Such motor improvements persisted for up to two months, at which time the animals were killed so that their brains could be examined. More studies are needed to see if the improvements are permanent.

The researchers used tissue implanted from fetuses under the assumption that it has a better chance of taking root than does tissue from adults. Since fetal tissue is still growing, it can respond more vigorously to chemical changes and thus form connections with the other brain cells.

Of Mice and Rats

In any transplant, the closer the donor and recipient are genetically, the better the chances that the foreign tissue will not be rejected. So transplants between individuals of the same species are easiest. But Joseph Wells and his colleagues from the University of Vermont report that they have successfully transplanted brain tissue from mice into the brains of rats. They first damaged the rats' hippocampus, a part of the brain involved in learning and memory. This impaired the rats' ability to learn a simple T-maze. The researchers then put brain cells from embryonic mice into the lesioned areas in the rats' brains. Afterwards the rats could learn the maze as well as normal rats.

All these experiments were done without immunosuppressant drugs, which carry side effects. The brain is an "immunological privileged" site since it has limited exposure to the lymphatic system controlling the immune response. This means that normal immune reactions

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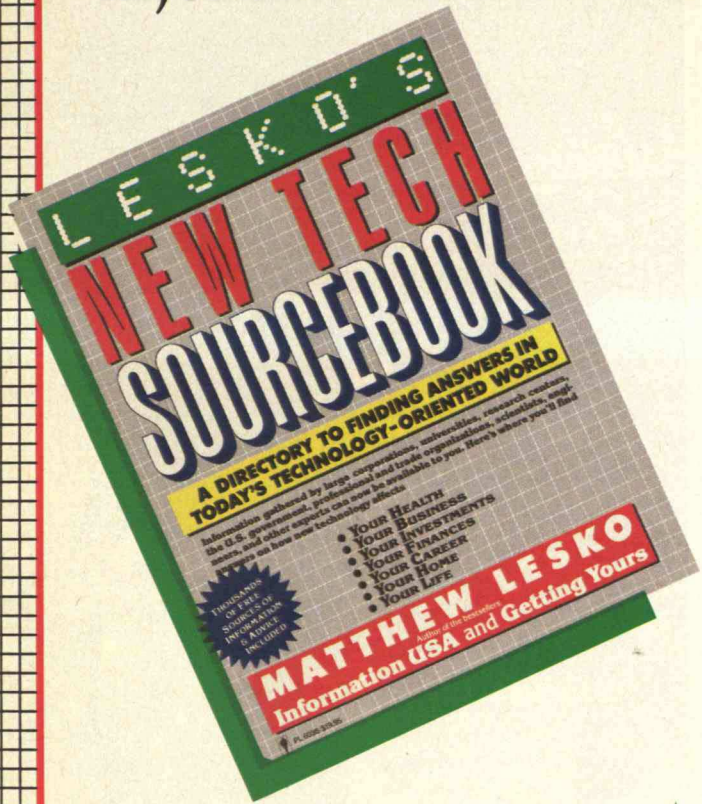

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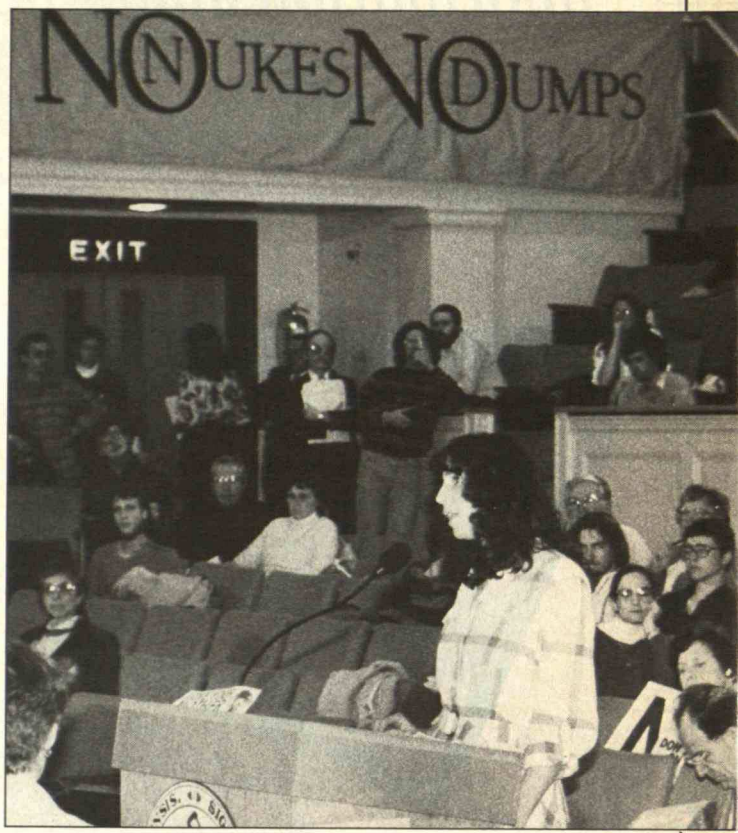
that are responsible for tissue rejection do not work as effectively as in other parts of the body. As a result, transplanted tissue is less likely to be rejected, and brain implants are simplified.

Although the studies indicate that implants may be beneficial, it is not clear whether newly introduced cells actually made functional connections with the other brain cells. The improvements could be due to a general increase in brain chemicals produced by implanted tissue. The ability of implants to replicate the complex connections among neurons in the brain may eventually limit the clinical use of these procedures.

Because the research is performed with fetuses, it raises moral issues. The prospect of transplants from other species answers some potential objections from those who fear human fetuses are endangered, and other alternatives are possible. Brain cells that can be grown and maintained in the laboratory might also provide an alternative. And Swedish doctors recently demonstrated another technique. They implanted pieces of the adrenal gland into the brains of patients with Parkinson's disease. Like the substantia nigra, the adrenal gland, which lies atop the kidney, produces dopamine and dopamine-like chemicals.

Since 1982 four patients have undergone the highly experimental surgery. In all four, the symptoms of Parkinson disease have been temporarily alleviated. Though inconclusive, these results indicate that brain implants could come from other kinds of tissues—as long as those tissues produce the same chemicals the brain does.

—David Liskowsky



High-Level Furor

The Nuclear Waste Policy Act (NWPA) of 1982 calls on DOE to plan the construction of two permanent dumps for the nation's high-level nuclear waste. The authors of the act intended that one dump would be located in the West, the other in the East.

In January 1986, DOE announced 12 possible Eastern sites, causing a furor in the states involved. In a surprising move, DOE reversed itself on May 28, "indefinitely postponing" the search for a high-level waste repository east of the Mississippi. That decision, while preempting protest in the East, has spurred fresh challenges to the waste-disposal program.

In the next decade the amount of high-level nuclear waste is expected to almost triple. Already 12,000 tons of highly radioactive spent fuel rods lie in cooling pools at nuclear-power plants across the country. Because the waste is so hazardous, DOE believes that it should be isolated from the environment and human contact for at least 10,000 years, necessitating a permanent disposal facility.

Prior to NWPA, the lack of a national plan for disposing of nuclear waste threatened to halt the growth of the nuclear power industry. California, Wisconsin, Massachusetts, and other states had even passed laws prohibiting new plant construction until a safe disposal method was demonstrated. The nuclear-power industry, intent on dispelling this concern, was a major driving force behind the enactment of NWPA. To show that nuclear waste could be handled safely, Congress stipulated an explicit and strict schedule for establishing the two dumps.

Under NWPA, DOE must develop plans for two permanent, so-called "deep geological" repositories, 1,000 to 4,000 feet deep. Each is expected to cost $6 billion to $9 billion. The Western site is to be ready in 1998, and before DOE's turnaround, the Eastern repository was scheduled to follow about seven years later. The act also puts a 70,000-ton cap on the amount of waste allowed at the first repository. The cap is intended to assure candidates for this site that an Eastern site will be built to share the burden.

DOE Changes Course

In dropping plans for the Eastern dump, DOE cited the expense of the search, satisfactory progress on selecting the Western repository, and revised projections of the amount of nuclear waste that will be generated. The May 28 announcement stated that DOE had also narrowed further its choices for the Western repository, selecting three sites for more extensive testing in Utah, Texas, and Washington. DOE's announcement came just a month after its adamant rebuttal of a similar proposal to build just one repository. Thus the turnaround raised questions in Washington about the legality of DOE's move and the rationale behind it.

Many public officials in

PHOTO: ELLEN SCHUB

The announcement of possible sites for an Eastern high-level nuclear waste dump sparked widespread opposition.

these states feel that DOE is violating the political compromise that was essential to the passage of NWPA. That agreement stipulated that an Eastern site would follow the Western one.

Critics charge that the department's reversal was motivated by widespread protest in the East rather than technical criteria. Nevada Governor Richard Bryan says DOE's change of heart "smacks of politics. In the interest of fairness, the burden should be shared." In places such as Naples, Me., and Asheville, N.C., public meetings drew thousands of concerned citizens this spring. Large community groups organized and, within a few months, raised hundreds of thousands of dollars. Wisconsin Governor Anthony Earl told the House Subcommittee on Energy Conservation and Power, "We haven't purchased any F-111s yet, but we expect to use every technical and political resource at our command in order to keep this dump and all of its problems out of Wisconsin."

The nuclear-waste issue also increased public sentiment against the industry as a whole. In 1980 and 1982 citizens had voted to keep Maine Yankee, that state's one nuclear plant. However, an Associated Press poll, conducted in the midst of both the siting dispute and the Chernobyl accident, found that 58.5 percent favored closing the plant immediately. Governor Joseph Brennan, a proponent of nuclear power, has appeared in the industry's ads, but at his request a study has been recently completed on the costs of shutting Maine Yankee down. Brennan has stated that he is reconsidering his support of the reactor. "Isn't it logical to say that if we don't want [a nuclear-waste repository] here, you should say we close that plant?" he asked an audience of 2,300 at a spring DOE hearing.

Rep. Edward Markey (D-Mass.), chair of the House Energy Conservation and Power subcommittee, plans hearings on DOE's reversal. He has asked the agency to supply information that will "convince the American people that science and technical considerations and not politics" were the reasons behind its decision. Markey says he is particularly troubled by DOE's intention to postpone rather than terminate the second repository. "The decision reflects a curious turnaround by an administration that adamantly opposed such a halt at our subcommittee's hearing just one month ago. We need to know all the details behind the decision, and whether any deals have been struck."

Markey and others are particularly concerned about a meeting between Donald Regan and Republican leaders in Congress that occurred just before the May 28 announcement. Some sources suggest Republicans were worried the dumps might be an election-year issue, especially in Maine and New Hampshire which have early primaries and caucuses for the coming presidential election. "Will the postponement suddenly end after Election Day?" Markey asks.

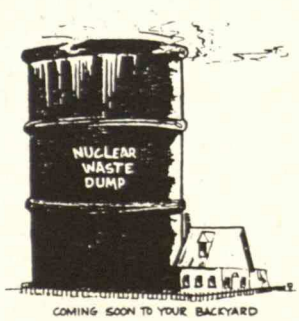
Compromise in Jeopardy

By dropping the Eastern site, DOE has drawn criticism even from its former supporters in the West. The state of Washington, which previously endorsed the site-selection process, has joined Nevada to challenge DOE in court. The plaintiffs maintain that DOE's current actions will lead to violating the cap on the amount of waste allowed for the first repository. DOE now projects that by the year 2020 approximately 84,000 tons of high-level waste will have been generated, 14,000 over the cap.

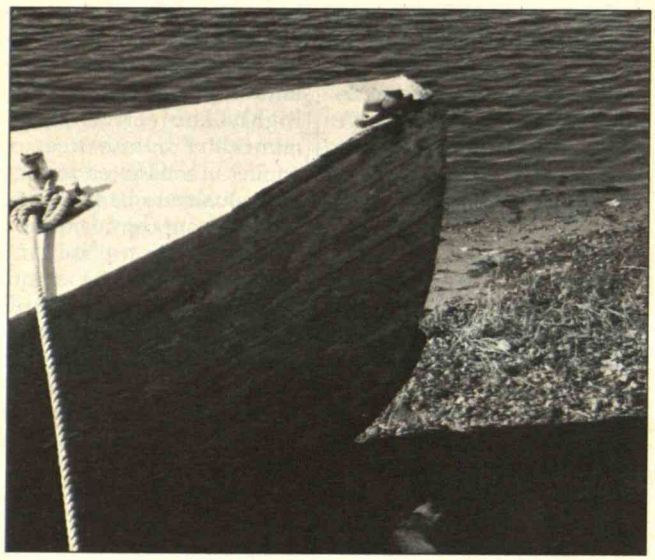
Texas is suing DOE as well, aiming to block the choice of the salt bed in Deaf Smith County. The state contends that this site threatens the Ogallala aquifer, an important source of water for agriculture and drinking. And the Environmental Policy Institute (EPI) is awaiting a decision on its suit challenging DOE's site-selection guidelines. David Berick, director of EPI's Nuclear Waste and Safety Project, says the guidelines allow "DOE to make highly subjective judgements." For instance, no aquifer in the United States is too valuable to be totally exempted from consideration.

Also facing criticism is a provision of NWPA stating that DOE will take responsibility for the utilities' nuclear waste in 1998. It appears likely that no site will be ready then, so DOE may end up paying the utilities to continue to store the nuclear waste themselves.

A number of members of Congress believe DOE's recent decision violates NWPA. Recently introduced legislation would halt the siting process entirely until the second tier of sites is reinstated. Meanwhile, more than a dozen members of the House and Senate have written energy secretary John S. Herrington questioning the legal basis for eliminating the Eastern site. One of the letter's authors, James McClure (R-Idaho), co-sponsored the bill creating NWPA. He thinks DOE's actions may violate NWPA, but opposes opening the act for amendment. McClure, other supporters of NWPA, and new and old critics are aware that the delicate political balance that produced NWPA may be impossible to rebuild.—*Dan Grossman and Seth Shulman*



Modern paints prevent algae and barnacles from growing on ships, but they may also threaten valuable marine life.



Death to the Slime

For more than a decade, paints containing tributyltin (TBT) have been widely used on commercial ships and pleasure craft to stop the growth of algae, barnacles, and other unwelcome guests. However, Michael Champ, science advisor at the Environmental Protection Agency (EPA), calls TBT "the most toxic thing we've ever added to the marine environment."

More than 4,000 different fouling organisms attach themselves to the bottom of ships. By increasing friction, they slow vessels down and thus increase fuel consumption. A film of slime only four-thousandths of an inch thick on a super tanker costs about $1 million annually.

Shipowners used to rely on toxic paints containing copper compounds to fight slime films and the barnacles that succeed them. But TBT is 10 to 100 times more effective, and in the early 1970s paints made with this pesticide became popular. Presently, the United States produces 1 million pounds of TBT each year. About a third of it goes into anti-fouling paints.

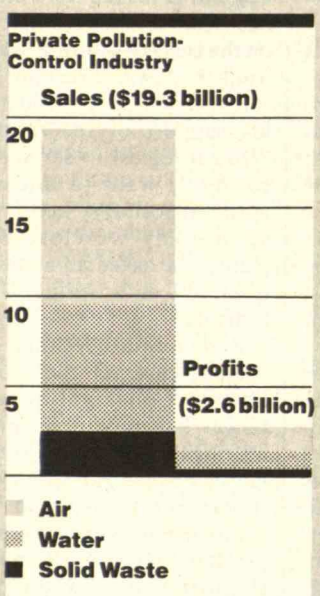
The problems occur when TBT leaches out of the paints. Robert B. Foster, laboratory director for Springborn Bionomics, an environmental toxicology and chemistry laboratory, says their tests show that TBT kills oysters at concentrations as low as 100 parts per trillion. Freshwater fish are affected by 1 to 10 parts per billion.

Fortunately, technology is reducing TBT pollution. Simple tributyltins were mixed directly into early paints. TBT was released rapidly into the environment, and boats had to be repainted every two to three years. In the newer co-polymer paints, TBT is bound to a complex organic polymer, so that it is released more slowly. Such products release approximately one-fiftieth as much TBT, claims Tom Gibbons, manager for the marine division of International Paint, which manufactures TBT-based paint.

Tributyltin co-polymers can also be combined with ablative coatings, a technology developed in the 1960s. Ablative coatings are designed to gradually wear off, taking with them any organisms that have started to grow. Because of this self-polishing action, ablative paints use even less TBT than co-polymer paints.

Despite these advances, the simpler TBT paints are still widely used. And TBT is still unregulated. "Right now there aren't really any controls," says U.S. Navy spokesman Stephen Pietropaoli. "These paints are sanctioned

CLEANLINESS PAYS: In the last two decades, nationwide concern for the environment has spawned a major industry called pollution abatement and control (PABCO). According to a study by Management Information Services, Inc. (MISI) expenditures for PABCO hit $70 billion in 1985, up from $18 billion in 1972. Of the 1985 expenditures, $8.5 billion represents private investment in environmental protection.



MISI estimates that the private investment alone generated 167,000 jobs and $2.6 billion in corporate profits in 1985, providing "support for some mature industries presently suffering from stagnant sales and foreign competition." For example, over 3,000 jobs were created in iron and steel manufacturing. Investment in PABCO provides "impetus to emerging high-technology industries" and plays "a disproportionately large role in expanding the job market for selected scientific, engineering, and technical personnel," MISI says.

California tops the list of states benefitting from PABCO, with an estimated 17,420 new jobs and $2,280 million in sales. New York is second (12,160 jobs, $1,641 million), and Texas third (11,570 jobs, $1,293 million). At the bottom are the District of Columbia (240 jobs, $39 million) and Alaska (340 jobs, $58 million).

INSURERS BAG IT: Air bags are still not standard equipment on cars, but insurance companies think they pay off now. *Status Reports*, a publication of the Insurance Institute for Highway Safety, says that these companies have ordered 2,500 autos equipped with the bags for their own fleets. In 1985 Travelers invested $5 million in air-bag-equipped autos, and it is adding 1,100 more vehicles this year.

Under current regulations, car manufacturers must start phasing in passive restraints for drivers in 1987. Acceptable restraints include air

PHOTO: FRANK LOWENSTEIN; CHART: OMNIGRAPHICS

for use by EPA. We estimate that 90 percent of the commercial fleet and the pleasure fleet are painted with them." Much of the current debate arose in June 1985, when the U.S. Navy proposed using TBT-based paints on its fleet.

One reason for TBT's continued popularity is that the adverse effects are not well documented yet. According to Foster, whose research was conducted in a laboratory, only one field study has detected important TBT effects. In that study, French researchers examined the Arcachon Basin, an estuary with a narrow mouth and restricted circulation. They found that concentrations of TBT in low parts per billion inhibited oyster-shell growth. But this data indicates little about the long-term impact of TBT. "Let's say something affects your growth by 10 or 15 percent," Foster explains. "Does that adversely affect your whole life?"

Gibbons argues that lab experiments may exaggerate what happens in the natural world, where currents, sediments, organisms, and other

MINITRENDS

bags and automatic seat belts. Similar protection for the front-seat passenger is scheduled to begin in 1989. Ford, which offers air-bag systems on its Tempo and Mercury Topaz four-door sedans, wants the government to delay restraints on the passenger side. This, says Ford, will make it possible to focus on supplying the driver's side of most cars with air bags by 1989. Technology to protect the passenger could be developed in the meantime.

Last year, five Travelers employees were in crashes severe enough to activate their air bags, but not one person was injured. "Looked at from a purely economic point of view, our investment has already paid for itself. The hospitalization and rehabilitation costs, lost work time, or possible death benefits would have exceeded the actual cost of equipping our cars with air bags," says Peter Libassi, Travelers' senior vice-president.

Government agencies are coming to the same conclusion. The General Services Administration purchased 5,300 Ford Tempos equipped with air bags, and state and local governments bought 550 more. In all but one of the 60 crashes involving these cars, only a few moderate injuries occurred. In the exception, the driver was killed when a logging truck hit the car head on and ran over it.

MOSQUITO MAPS:

In a marriage between high technology, mapping, and epidemiology, Marc Imhoff and a team from Goddard Space Flight Center are developing a concept that could reduce disease in Africa. They are analyzing radar images to map insect breeding grounds and disease-transmission areas. They believe the data could not only help improve the health of humans and livestock but further research in drought and famine relief.

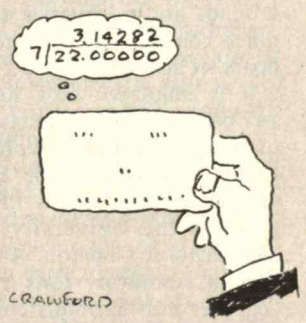
In 1984 NASA's space shuttle demonstrated that radar could penetrate jungle vegetation and expose water ponds. Taking a lower-tech approach, the current Goddard project will use radar-equipped airplanes, revealing even better detail of land features. It will detect the "dambos" where insects breed—areas of stagnant water created during the rainy season when swollen streams flood surrounding grasslands. A satellite project headed by Itek Corp. used similar technology to look for water under deserts.

"Our goal," Imhoff explains, "is to demonstrate that disease control can be greatly enhanced through routine remote sensing." The primary target for the project, which is scheduled for the 1987 African rainy season, will be the breeding habitats of mosquitos.

SMART CARDS:

It's a credit card with an imbedded microprocessor that gives it computing power and the ability to store large amounts of information. The so-called "smart card" can, for example, be used for eletronic banking and shopping, identification, personal data bases, and encrypting devices.

In France, where the smart card was developed, bank card companies have accepted it as the industry standard and 12 million will soon be in use. In the United States VISA International has a contract with Toshiba, while



MasterCard is conducting field trials on consumers and projects nationwide use of smart cards in 1987.

Business Communications Co., a market research firm, predicts that 127 million smart cards will be in use by the early 1990s. Most will be issued by financial services such as the credit-card companies. Two factors push the development of the technology. First, rising telecommunications costs have made credit verification more expensive. Second, the smart cards should make credit card fraud—which costs the industry over two billion dollars a year world-wide—more difficult. Developers say the integrated circuit is extremely resistant to tampering, making it unlikely that even an expert could tamper with the information on the card.

PHOTOS: FORD; ILLUSTRATION: MICHAEL CRAWFORD

chemicals affect the toxicity of TBT compounds. On the other hand, Bob Huggett, chair of the Chemical Oceanography Department at the Virginia Institute of Marine Sciences, notes that such factors may actually increase the toxicity of TBT compounds.

In general, laboratory experiments show that oysters may be the most threatened species. They also show that larvae and eggs are more sensitive than adult organisms, which is particularly troubling: the highest concentrations of TBT probably exist in the breeding grounds of fish and shellfish. Those breeding grounds are in estuaries and other coastal waters, where boats sit at docks.

It is unknown how long TBT persists once it enters estuaries and oceans. Joseph J. Cooney, director of the Environmental Sciences Program at the University of Massachusetts-Boston, says that in laboratory tests TBT degrades into harmless compounds when exposed to sunlight. "But those conditions are a long way from the real world," he adds.

Cooney suspects that in the marine environment bacteria may convert tributyltin into less toxic methyl tins. However, these tins are still "about as toxic as methyl mercuries, and methyl mercuries are pretty toxic." And, Cooney points out, methyl tins are more soluble in water than butyl tins. So they may be more widely distributed in the environment.

The Navy's 1985 proposal to repaint its entire fleet of 550 ships over 10 years would save $150 million in fuel costs and $5 million in maintenance costs annually. This proposal met with resistance even though it called for the safer co-polymer paints and the navy's environmental assessment predicted "no significant impact." "The Chesapeake Bay is the home of the largest naval facility in the United States," notes Huggett. Since the bay also produces about a fourth of the nation's oysters, he adds, "anything that might threaten those resources is looked at with a very calloused eye."

Prompted by such concerns, Congress withheld funds for the Navy program, stipulating that EPA must first complete a study of TBT's effects on the marine environment. EPA's "special expedited review," begun in 1986, could take up to three years.

Speaking for International Paints, Gibbons says he hopes that EPA will approve co-polymer paints. In his view, banning all TBT-based paints would lead U.S. shipowners to service and paint their ships in countries where TBT is legal. A ban, he says, would be a special hardship to owners of vessels too small to take elsewhere. Moreover, he observes that scientists are developing a new generation of anti-fouling paints without TBT or other toxic compounds. He believes these paints will be available commercially in a couple of years.

Meanwhile, EPA's Champ feels it is important to educate the public about the dangers of TBT-based paints. He encourages the use of the more sophisticated co-polymer paints, especially on small craft. Such boats usually sit in harbors more, threatening the vital ecosystems of estuaries. Harold Guard, scientific officer at the Office of Naval Research, concurs. "I think the real focus of environmental concern will tend to be the pleasure craft. Commercial craft are under way or they don't make money," he explains.—*Frank Lowenstein*

Engineers Want To Be...

The nation's 1986 engineering graduates follow a growing trend: more and more of them have aspirations that go beyond computerized work stations and engineering laboratories. They are yuppies in the original sense of the word, says Robert K. Weatherall, choosing engineering because they see it as a good jumping-off place for other careers.

"They are attracted to the fast track and the front office," notes Weatherall, who is director of placement at M.I.T. As part of a study last spring of the impact of the defense build-up on non-defense engineering employment, Weatherall was asked by the National Research Council's Office of Scientific and Engineering Personnel to survey his colleagues in leading engineering schools throughout the country about students' views of the job market. Where are students taking jobs this year? What are their interests? Their goals?

The answers to questions about jobs were as varied as the schools from which the students came. But on goals there was unanimity: more and more engineering students are looking for more than engineering.

Purdue students are loyal to their region; they are drawn in general to local industries and in particular to the heavy manufacturing south and east of Chicago. Defense or nondefense, high-technology or low-technology are not really serious issues. It's the same story at the University of California at Los Angeles (UCLA), surrounded by large military contractors: no prejudice against defense. In fact, most graduates take defense jobs.

Not so at the University of California's Berkeley campus, where during the spring students demonstrated against recruiters from General Dy-

namics and the Central Intelligence Agency. The companies of Silicon Valley are the big recruiters in Berkeley—and at Stanford, where there is also considerable hesitation about working in defense, according to James Patterson of the Stanford placement office. The same antipathy to defense shows up at Oregon State, says placement director Tony van Vliet. But a shortage of regional jobs forces Oregon State students to look farther afield, and many take jobs with southern California defense contractors.

Most Eastern schools report little prejudice against defense. The University of Maryland is just 10 miles from the Pentagon, and Linda Gast of the school's Career Development Center reports that 60 to 70 percent of electrical-engineering and physics graduates take jobs with military contractors in the area. Indeed, she says, Maryland students "hold the defense establishment in very high esteem." Similarly, Rensselaer placement director Vicki Lynn characterizes many students as "excited by state-of-the-art defense technology. . . . There is a resurgence of patriotism," she says, and most of the students are "gung-ho."

At Georgia Tech, "manufacturing is more sexy than it used to be," suggests placement director James Osborne. The most exciting opportunities are in high-volume production, and that means chiefly civilian industry. But at the same time, there is a "definite increase" in defense recruiting and no real prejudice against defense jobs—just some hesitancy owing to the ups and downs that resulted in the layoffs of the early 1970s.

At M.I.T., where some faculty members are outspoken opponents of Star Wars and others are prominent consultants on defense, engineering students divide themselves into two categories. Most are interested in traditional engineering careers, and they head for commercial and government-contract employers. In the present marketplace this "for the most part means defense firms," says Weatherall.

However, a growing proportion of M.I.T.'s engineering graduates expresses aspirations beyond engineering. They are "increasingly interested in employment in which they will be interacting with other people. They want to become managers and decision-makers," Weatherall observes.

The same distinction is made by Weatherall's colleagues. Chenits Pettigrew, placement officer for UCLA's engineering school, says that many students choose engineering not because they are "passionate" about the field but because it looks to them like "a way of gaining organizational access." Van Vliet at Oregon State and Patterson at Stanford point to many engineering students' "entrepreneurial ambitions and their desire to manage." Students are looking at civilian-sector jobs, especially in small companies or with non-traditional employers such as management consultants and financial companies.

The bottom line, says Weatherall, is that few of today's engineering students fit the uni-dimensional mold in which most educators and employers cast them. They are attracted not by engineering itself, but rather by the access it provides to "broader, more varied work and more glamorous, rewarding careers."—*John Mattill*

Hydro: Past or Future?

During the 1970s, when energy resources seemed to be dangerously scarce and dauntingly expensive, Americans took a second look at thousands of small, abandoned dams spotted around the Northeast and Northwest. These dams had generated power early in the century, but fell idle when bigger, more centralized fossil-fueled generators took their place.

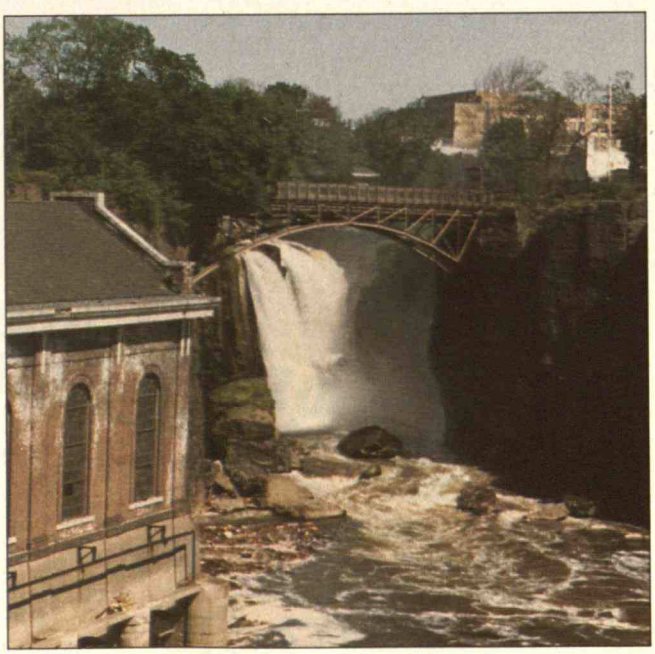
In 1978 the Public Utility Regulatory Policies Act (PURPA) made these old dams and powerhouses financially feasible again by making the utilities purchase their power. The rush to redevelop small-scale hydropower was sparked. Expectations were high in what industry folklore calls "the gold rush days."

Now the industry's outlook is rock bottom. Many observers predict the end of development of small-scale hydropower. But just as the early expectations were too high, today's gloom may be excessive, too.

Creating an Industry

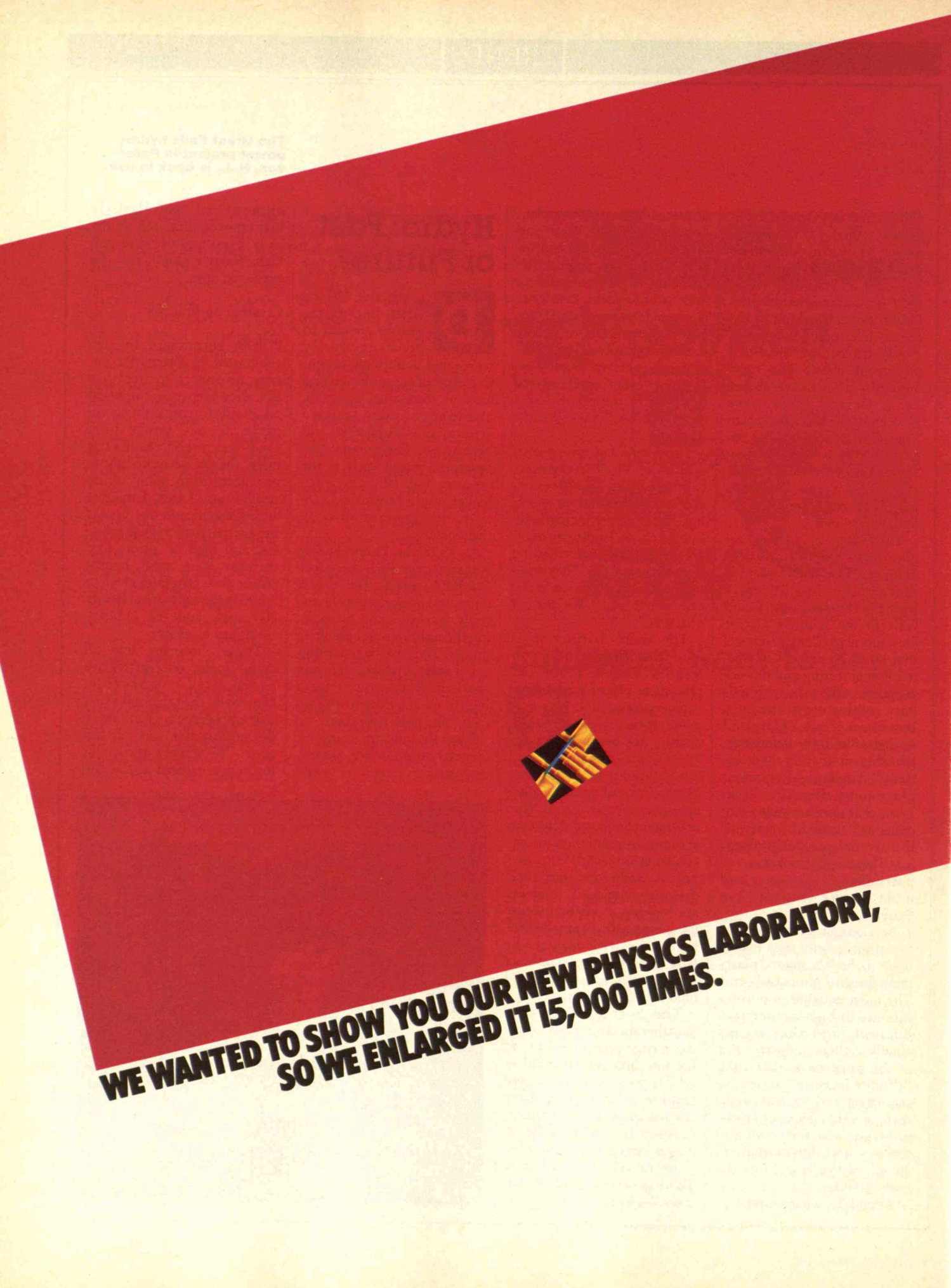
PURPA encouraged the development of alternative energy resources to decrease U.S. dependence on imported oil. Beside forcing utility companies to buy power from small-scale producers at a fair price, the act exempted those producers from many utility regulations. Later, Congress added significant tax breaks for alternative energy producers, and high oil prices iced the cake. As a result, hydropower now generates close to 2,000 megawatts from nearly 200 sites, and the industry continues to grow.

Today, however, low oil prices make once-attractive hydro sites unworkable. Moreover, the tax breaks that sent entrepreneurs running to the nearest dam are all but gone. The energy tax credit for hydro expired at the end



The Great Falls hydropower project in Paterson, N.J., is back in use.

PHOTOS: SYNERGICS, INC.


WE WANTED TO SHOW YOU OUR NEW PHYSICS LABORATORY,
SO WE ENLARGED IT 15,000 TIMES.

Scientists at AT&T Bell Laboratories have created a "laboratory" on a chip—featuring a functioning transistor only 200 atoms wide.

This new transistor—a laboratory in which microscopic circuits reveal the fundamental nature and behavior of electrons—enables us to explore the physical limits of miniaturization.

Shrinking Pains

Miniaturization is one key to increasing power, capability and speed in an integrated circuit.

But there's more to shrinking a circuit than making it smaller; there are new problems created by the laws of physics. One of the most troublesome is noisy electrons.

Just as electrons can carry information through the transistors of a circuit, they can also make noise. And, as circuits get smaller, noise becomes more of a factor, even to the point of "drowning out" the information.

What's All This Noise About?

To ensure that smaller will continue to mean better, AT&T sought a new way to isolate, understand and control electron noise.

Utilizing an advanced method of precision engraving, chips were carved with the record-breaking 200-atom-wide transistor circuits—so small they force electrons to flow in nearly single file.

This micro-laboratory makes it possible to segregate, manipulate and "tune-in" on individual electrons. (Listening to electrons one at a time is like listening to the clapping of one person in the crowd at the Olympics.) By studying electron flow at this minuscule order of magnitude, AT&T has produced some fundamental revelations about the sources of circuit noise.

The Rocks In The Rapids

As electrons move through the narrow circuit, they behave both like waves and like particles. The particles can be troublemakers. Some produce obstacles in the form of charged atoms—atomic "rocks" that create disruptions in the flow of current, much the way rocks create the "rapids" in a stream.

Noise—in the form of individual "clicks"—comes from sudden changes in current flow as single electrons create and destroy atomic "rocks." Now, using our narrow-channel transistor to study these disruptions in current flow, we are able to identify the individual clicks that comprise data-obscuring noise in ultra-small circuits.

Listening to electrons one at a time.

Quiet! Electrons At Work

Identifying the source of electron noise is a big step toward removing it. But, AT&T is already working on the next step—experimentally altering the nature of atomic obstacles to reduce their effects.

As the number of components on silicon integrated circuit chips continues to increase—by a factor of as much as 100 each decade—a knowledge of noise becomes critical. Today, AT&T packs 2 million components into its megabit memory chip; by the late 1990s, 100-million-component chips should be possible.

A consistent world leader in microelectronics, AT&T will continue to probe the physics of the very small, building on the advanced research made possible by a laboratory on a chip.

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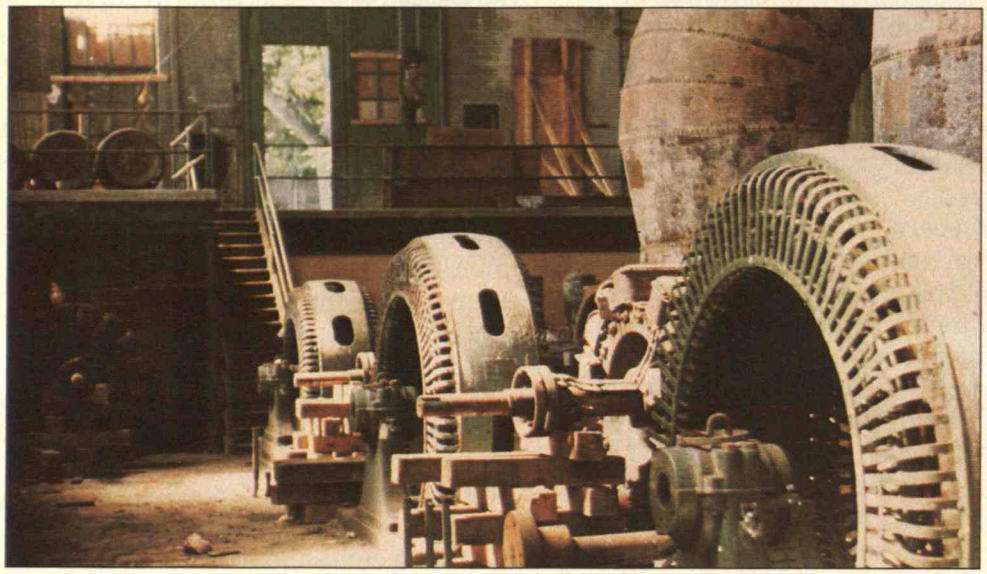
AT&T

The right choice.

Before the return of hydropower, the machinery inside the Great Falls project had fallen idle.



of 1985. Tax reform in Congress will probably take with it the investment tax credit and favorable depreciation rates.

Finally, environmental concerns, which once contributed to hydro's attraction, now threaten many projects. Excellent environmental arguments for development still exist: hydropower is clean, safe, renewable, and reliable. But problems have emerged. These include ensuring successful migration of fish around dam sites, keeping fish away from turbine blades, maintaining adequate instream flows to support recreation and animal life, and resistance from environmentalists to damming up undeveloped stretches of rivers.

In the 1970s, the energy crisis pushed regulators to find a middle ground between solving environmental problems and satisfying the need for renewable energy. The sense of crisis has since diminished, so regulatory agencies are less supportive of hydropower. In 1985 the Federal Energy Regulatory Commission (FERC), which licenses all power projects, changed the rules governing its licensing process. To be considered for an FERC license under the new rules, a developer must consult with—and have the approval of—local and state environmental regulators. In some states, this process is now well-nigh impossible to get through, even if a project is environmentally benign. Oregon is a prime example, having passed very tough anti-development laws in 1985.

Although some hydroelectric developers believe that the new FERC rules cede too much power to state agencies, many environmentalists accuse FERC of not being tough enough. In 1983 a coalition of environmental groups—including the Sierra Club, National Wildlife Federation, and National Audubon Society—asked the commission to give PURPA benefits only to existing dam sites. The coalition claimed that this would reflect the original legislative intent. When FERC did not respond, the coalition went to court to get an answer. The court in December 1985 gave FERC 90 days to act, and the agency reiterated its original position.

The coalition then requested that FERC do a major new study on the environmental impact of all hydro development. FERC answered that all potential sites are closely scrutinized for problems, that its Cumulative Impact Assessment Procedure monitors the effects of multiple-river basin sites, and that it already has a major impact study underway. The coalition considers these efforts insufficient and has gone back to court to force FERC to reopen the rules for granting PURPA benefits.

Congress Reconsiders

The ubiquitous description for the mid-1980s is "shakeout." The licenses for 65 existing projects, together generating about 700 megawatts, will expire in the next five years. Bills that establish standards for relicensing older dams have been passed by both houses of Congress and are currently in conference. Attached to these bills are provisions that would severely restrict the building of any new dams. The Senate version would allow new dams only on federally owned land, and only if they meet conditions set by fish and wildlife agencies. The House version puts a moratorium on all new dams until a study of PURPA benefits is completed.

In response to the more difficult market conditions, most developers who once embraced small-scale hydropower are gone from the scene. Those who remain approach the business with more sophistication. For example, Consolidated Hydro, Long Lake Energy Corp., and Catalyst Energy Development Corp. have made public stock offerings in the last six months. This move, unprecedented in small-scale hydro, puts their financing on a very different basis than relying on tax breaks.

The mom-and-pop operations are less in evidence; today's active developers can compete better because they own several sites and are looking for more. They will continue to consolidate, and some will continue to build, though the shrinking number of good sites will impose limitations. These survivors deal more effectively with environmental issues, choosing their projects judiciously and demonstrating both efficiency and good faith to regulators. By virtue of having developed several sites, these companies have established working relationships with agencies, bankers, insurers, and engineering firms.

In the long run, small-scale hydro's growth potential depends largely on when the energy shortage resurfaces, bringing high fossil-fuel prices. Public policy will no doubt reverse itself and re-establish the incentives that are all but gone today.—*Sarah Cliffe. The author is the former editor of* Hydro Review.

Frederick Wiseman will determine this antique's history from the pollen he is scraping off.

Pollen-Alysis

Could that moth-eaten $5 chair purchased at the local flea market be worth $100,000? Armed with a scalpel, a microscope, a few chemicals, and a book on pollen, Frederick Wiseman makes furniture tell the truth about its history. Wiseman, principal research scientist at the M.I.T. Center for Materials Research in Archaeology and Ethnology, combines his amateur's interest in antiques with his training in palynology—or "the study of ancient dust," as he puts it.

Pollen, the powdery, airborne "sperm" of seed plants, is ubiquitous. The minute particles lodge on everything. And, according to Wiseman, it is "a very persistent stuff" because it is coated with a complex organic molecule highly resistant to decay or destruction. "I call it a natural Teflon," he says. "It's just about as chemically inert."

Since pollen is crucial to reproduction, it is distinctive to each plant species. Once pollen grains on a piece of furniture are identified, forestry records can be used to pinpoint its geographic origins—and therefore those of the furniture. For example, white-pine pollen indicates that a piece spent time in New England or parts of Pennsylvania, since the tree is indigenous only to these regions. Wiseman notes that "out of the several hundred different types of pollen grains you find around here, there are 10 to 15 that are very diagnostic on furniture."

Before Wiseman developed his techniques, art historians and museum curators watched furniture for styles they had seen in other pieces whose history was known. But even detailed histories generated in this way could be heavily subjective. Some museum pieces tote a card that can only pretend to be knowledgeable about the furniture's past. At Yale debate over a chair's origin caused a schism: one faction of art historians thought it originated in America, the other believed it came from Ireland. Wiseman found no traces of European pollen on the chair, which proved that it was American.

Pollen analysis is so respected that law-enforcement agencies such as the FBI use it to identify the origins of drug shipments, trace stolen goods, and help find bodies. Wiseman's scholarly work on Mayan civilizations makes him an expert on Central American pollen, and he has helped in drug investigations.

To analyze pollen on a museum piece, Wiseman uses a scalpel to gently remove a dime-sized sample of the finish from the underside of furniture. Damage to the piece is kept to a minimum. He puts the scrapings through a series of acid and solvent baths to dissolve wax, varnish, and other minerals accumulated over the years. "Instead of separating the pollen from the matrix of dirt, I dissolve away everything but the pollen," he explains. With a skill he says takes years to master, he examines the grains under a microscope for 35 to 40 unique, identifiable traits. Using catalogues that list the features of pollen from different geographic locations, Wiseman can determine where the furniture has been.

The most colorful example of Wiseman's simple technique involves the three-year quest of Barry Courtney, an expert on Early American furniture. Courtney wanted to prove that his maverick, high-backed, Windsor-style chair is American. Other specialists laughed at Courtney's appraisal, judging the chair to be a late nineteenth-century English reproduction of the classic American Windsor style.

Courtney uncovered an article by Wiseman that described basing analysis on hidden attributes rather than visible data. Courtney contacted Wiseman, who offered his help. From two scrapings he concluded that the chair had indeed been manufactured in America. "My analysis showed there was no English pollen at all. Not a touch," says Wiseman. "If it was English in origin, we would expect to find heather or English ivy pollen."

This showed that the chair was an American original, but did not prove that it represented a particular period in Windsor furniture. For this the chair had to be dated and, once again, Wiseman's dust expertise was instrumental. Before kerosene was introduced in about 1860, most homes used lamps that burned lard or sperm-whale oil. These lamps burned clean but emitted a cloud of fat or oil when extinguished. The oily clouds coated everything in a room. Wiseman analyzed the fats and oils that merged with the chair's finish and concluded that the piece, coated with lard oil, is a pre-1860 American original.

—Todd Renshaw

PHOTO: CHRISTOPHER CRAIG

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ROBERT C. COWEN

Tough Choices Ahead for NASA

NASA has its marching orders. But nobody's told the troubled agency where it should go. In June, President Reagan asked NASA administrator James Fletcher to implement the recommendations of the presidential commission on the Challenger accident. However, Reagan has yet to act on the report of the other presidentially appointed commission—the National Commission on Space. This commission is concerned with the long-term U.S. goals in space.

These two comprehensive reports should be considered together. The Challenger tragedy has taught us that a well-intentioned space program can be disastrous without clear goals to guide it.

In investigating the accident, the Challenger commission wisely refrained from a witch hunt. Congress, NASA, and past and present administrations share the blame for a situation in which some kind of shuttle disaster seemed inevitable. If it wasn't a leaking rocket joint, it could have been broken brakes, blown tires, or an exploding main engine. It could even have been an unmanageable hydrogen-oxygen-powered booster for the Galileo Jupiter probe, which a shuttle was to carry into low-earth orbit this year. All of these have emerged as unacceptable risks that NASA tried to live with under pressure to make the shuttle operational.

On July 4, 1982, President Reagan announced that "the first priority of the STS [shuttle] program is to make the system fully operational and cost-effective in providing routine access to space." Congress and the executive Office of Management and Budget followed with annual budget reviews that pressed NASA to cut costs and speed up the launch schedule. Shuttle officials needed no last-minute pressures to launch the Challenger incautiously. They were already under enough pressure to ignore long-standing safety warnings.

NASA was also caught in a bind of its own making. It had unrealistically sold the shuttle as a cheap trip into orbit. It had promised launch costs of about a hundred dollars per payload pound, but today those costs run to several thousand dollars per pound. To maintain the shuttle, NASA persuaded the White House and Congress to phase out unmanned rockets. Only the air force was allowed to keep a few such rockets in reserve. The shuttle became virtually our sole means of gaining access to space—access that a single accident could foreclose.

Such are the fruits of a program without overarching goals. In the late 1960s and early 1970s, NASA administrator Thomas Paine wanted a post-Apollo program that would employ a reusable spacecraft to build a space station and other infrastructure. Establishing moon bases and making a manned expedition to Mars was the ultimate goal. Neither he nor his successor, James Fletcher, found a constituency for this vision. Fletcher won only lukewarm White House support for the shuttle.

Reviewing shuttle history in *Science*, space policy analyst John Logsdon of George Washington University writes, "The shuttle was intended to be a national capability . . . but the decision to develop it was made through the 'normal' political process of bargaining, compromise, and coalition building, not on the basis of presidential leadership." As a result, the shuttle program was constantly beset by budget cuts and delays. Making the shuttle "operational" became an end in itself, and eventually an obsession.

The Challenger disaster has now given the United States a chance to rethink its space policy. And the National Commission on Space, chaired by former NASA administrator Paine, has come up with a report full of suggested aspirations.

The commission identifies three national goals for the space program: science, including space astronomy, planetary exploration, and a detailed global study of planet Earth; human settlement of the solar system; and the development of space commerce. To achieve these goals, the commission suggests a "phased approach" that would start with a permanently manned space station in low-earth orbit and a new series of launch vehicles capable of lifting passengers and cargo into orbit at less than one-tenth the cost of the space shuttle. The report envisions the eventual construction of interplanetary factories using raw materials mined from the moon and asteroids, and ultimately permanent outposts on the moon and Mars.

The commission figures the cost of this ambitious program would nearly triple the annual civilian space budget to something like $20 billion [1986 dollars] by the year 2000. But the commission says that such a budget would take up a "modest" 0.5 percent of the U.S. gross national product, which it assumes will grow 2.4 percent a year. In fact, 0.5 percent is a little over twice NASA's current share of GNP. However, it's less than half the percentage the agency garnered during the peak Apollo years.

The United States has to face up to the cost of space pioneering and make some choices. Do we want to pursue manned orbital flight as a matter of national pride and international leadership? Would we prefer to emphasize unmanned scientific research? Do we eventually want to lead a world expedition to Mars? Different aspirations carry different price tags. Pursuing all of these programs would cost far more than NASA's current annual budget of $7.3 billion. And that says nothing of the military space program whose annual budget already is twice as large as NASA's. With the shuttle program, NASA made the mistake of trying to do more than the political system was willing to afford.

NASA chief Fletcher promises to "make America proud again." That begs the question: proud of what? Reagan, NASA, and Congress should decide what they think the United States should do and why. They need to present a well-articulated set of goals to the American public and provide the leadership to win support for those goals. Otherwise, the U.S. space program will continue to flounder. □

ROBERT C. COWEN IS SCIENCE EDITOR OF THE CHRISTIAN SCIENCE MONITOR *AND FORMER PRESIDENT OF THE NATIONAL ASSOCIATION OF SCIENCE WRITERS.*

ILLUSTRATION: BRUCE MADDOCKS

LESTER C. THUROW

Why the Ultimate Size of the World's Population Doesn't Matter

THE world's rapidly expanding population is often discussed as if it were an economic problem. What is the maximum number of people that the world can feed? Unfortunately, that isn't the relevant question. The issue is how fast the world's population grows, not its ultimate absolute size. And the ultimate number of people that the world can adequately support depends on lifestyle.

If the world's population had the productivity of the Swiss, the consumption habits of the Chinese, the egalitarian instincts of the Swedes, and the social discipline of the Japanese, then the planet could support many times its current population without privation for anyone. On the other hand, if the world's population had the productivity of Chad, the consumption habits of the United States, the inegalitarian instincts of India, and the social discipline of Argentina, then the planet could not support anywhere near its current numbers. Unfortunately, more people seem to fall in the American-Chad-Argentina category than in the former group.

Clearly, there is an intimate interaction between the number of people that a given area can support and the lifestyle of that area. This interaction can be seen in what was known in the early 1960s as the "minimum diet" problem. What was the minimum amount of money that an adult American would need to purchase a balanced diet for one year? Somewhat to their surprise, economists found it possible to buy a balanced diet for what was then $79 and would today be $283 per year. That diet, however, consisted of meals depending heavily on soybeans and lard with just orange juice and liver to provide the minerals, vitamins, and proteins missing in soybeans and lard.

Similar calculations can be made for heat or space. The Eskimos provide vivid evidence that not much of either is really necessary. If people were willing to live in the cheapest style consistent with a normal life expectancy, they would not need very much in the way of goods and services.

The problem is not what is economically feasible, but what is socially feasible. Are most people willing accept the assumptions that lie behind the minimum-diet problem—that no one should have anything above and beyond what he or she needs to be healthy? The answer is no, and that unwillingness is the real limit on the world's population. To push their own lifestyle above that minimum level, those that "have" are willing to watch those that "have not" starve.

Economic development depends on how fast population grows, not on its ultimate size.

The Acceptable California Lifestyle

These attitudes, of course, might change. Beliefs about what is acceptable and unacceptable in the end depend upon current circumstances and change over time and from place to place depending upon population densities.

The Japanese, for example, live in crowded conditions in apartments that Americans would find oppressively small. The Japanese have been socialized so that they don't find their homes oppressive. But they did not jump to their crowded lifestyle quickly. It evolved slowly over centuries out of necessity in a country whose population grew to be almost five times that of California in an area about the same size. If we very slowly increased California's population by a factor of five, the acceptable California lifestyle would also change. Those suburban yards and private swimming pools would disappear. Yet the Japanese have a high material standard of living. It is just different from the American standard of living.

However, neither Japan nor any other country became wealthy in the context of a rapidly growing population. Over the last 100 years, Japan's economic growth has averaged 4 percent per year while its population has grown at 1.1 percent per year. This produced a 2.9 percent yearly per capita increase in real standards of living that has made Japan one of the wealthiest countries of the world.

Over the last 100 years, the United States' growth rate has averaged 3.3 percent per year while its population has been growing at 1.5 percent a year. As a result, we have had a 1.8 percent per year growth in per capital income. Even though per capita growth in the United States has been much lower than that in Japan over the last 100 years, our per capita income is still noticeably higher. Japan was simply very far behind 100 years ago. In Germany the data show a similar pattern. Over the last 100 years the German economy grew 3 percent per year, its population grew 1 percent per year and its per capita income rose 2 percent per year.

These numbers indicate a fundamental problem for today's poor countries. Many of these countries have population growth rates between 3 and 4 percent per year. If Japan, Germany, and the United States had had such rates of population increase, their standards of living today would be no higher than they were 100 years ago. No country has ever become wealthy with rapid increases in population.

Investing in American Children

The reasons for this are simple. To make a new human being into a modern productive worker takes plenty of investment. And if there are going to be many new human beings, older human beings are going to have to be willing to hold down their personal consumption severely.

Continued on page 29

LESTER C. THUROW IS GORDON Y BILLIARD PROFESSOR OF MANAGEMENT AND ECONOMICS AT THE SLOAN SCHOOL OF MANAGEMENT AT M.I.T.

ILLUSTRATION: BOB DAHM

A U.S. spacecraft orbiting Venus made the first close-up views of Halley's Comet, giving scientists valuable insights into the comet at a time when it was on the far side of the sun and direct observations from Earth were impossible. NASA's Pioneer Venus Orbiter, built by Hughes Aircraft Company and circling Venus since 1978, conducted its investigation a month before five other spacecraft flew by the comet. The Orbiter was delicately repositioned with precise commands from Earth to observe Halley's at its closest point to the sun, a distance of about 55 million miles. The spacecraft measured changes in the comet caused by intense solar heating. It also provided an ultraviolet image of Halley's and its large surrounding hydrogen cloud. Data gathered by the Orbiter helped scientists determine the gas composition of the comet, the rate at which water vaporized, and the ratio of gas to dust in the comet.

The AMRAAM missile may become the next-generation weapon for protecting U.S. Navy surface ships against threats that have slipped through the outer defense shields. Sea AMRAAM, under study for ship self-defense, would be essentially the same as the Advanced Medium-Range Air-to-Air Missile in full-scale development by Hughes for the U.S. Air Force and Navy. However, compared with existing missiles, Sea AMRAAM would increase a ship's firepower because the missile's guidance system is much less dependent on the ship's radars. Many missiles could be fired at different targets simultaneously, and they could home in even if the targets were outside the field of the ship's radar systems. Sea AMRAAM is also faster, more maneuverable, and can fly farther than current ship self-defense systems.

An innovative digital receiver is being developed to alert military aircraft when they are approaching enemy radars and electronic warfare systems, thereby putting them at less risk while on a mission. The device, designed for electronic support measures (ESM), will be approximately 1/20 the weight and substantially smaller than current receivers. It will search for, intercept, record, analyze, and locate sources of radiated electromagnetic energy. The receiver can store this information. Or, if an enemy signal poses a threat, it can pass this information along to another type of electronic warfare system, such as a jamming device. Hughes is developing the receiver with independent research and development funds.

Cellular telephones may take a back seat to a proposed satellite system when it comes to making long-distance calls. The mobile satellite network, consisting of two Hughes HS 393 spacecraft, would relay two-way voice and data communications services directly from airplanes, cars, trains, or remote locations. While cellular telephone systems are limited to areas equipped with fixed antenna networks, mobile satellites would cover the continental U.S. and Canada, and possibly Mexico. Users would have their own mobile ground terminals. Hughes Communications Mobile Satellite Services, Inc. is seeking authorization from the Federal Communications Commission to operate the system.

Hughes needs engineers, scientists, and programmers to forge new frontiers in aerospace radars, weapon control systems and avionics, airborne displays, aerovehicle data links, and airborne countermeasures. Current openings are for people experienced in design, development, test and manufacture for systems engineering, project/program management, design of circuits and mechanisms, and bringing these to reality through the application of advanced manufacturing techniques. Send your resume to Hughes Radar Systems Group, Engineering Employment, Dept. S3, P.O. Box 92426, Los Angeles, CA 90009. Equal opportunity employer. U.S. citizenship required.

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BY FRED JEROME

Gagging Government Scientists: A New Administration Policy?

You tell people you're writing a column on our government's refusal to talk to the press during the Chernobyl crisis and they give you a quizzical look like maybe they didn't hear you right. "You mean the Russian government," they say.

No, you explain, it wasn't just the Russians who clammed up about Chernobyl. The U.S. government—specifically the Department of Energy (DOE) and the Nuclear Regulatory Commission (NRC)—issued gag orders instructing their employees, including scientists at the national labs, not to talk to journalists. But why, people ask, would our government do that?

Why, indeed? At the time, the American public was alarmed not only by the Chernobyl disaster itself but by the possible danger from a radioactive cloud moving this way. Soviet silence had aggravated the concern. At the Media Resource Service (MRS), we were fielding a record number of calls from the press. On one day alone, the Tuesday after the accident, 60 journalists called seeking scientific experts who would comment. While nobody had hard information on the actual accident, a number of experts were able and willing to comment publicly on a number of facts. For instance, they compared the design of Soviet nuclear plants to that of plants in the U.S. They discussed the nature of graphite fires. And they estimated the danger—or more correctly, the lack of danger—from the low levels of radiation reaching this country.

In the immediate aftermath of the accident, MRS referred at least 32 journalists to scientists at the national laboratories, including Oak Ridge, Sandia, Brookhaven, and Lawrence Livermore. According to the feedback we received, these scientists and many others were both knowledgeable and helpful. Reporters also called government scientists directly. Lawrence Livermore's first press call came at 8:00 A.M. on Monday from KCBS in San Francisco. Sue Stephenson, senior public-affairs officer at Livermore, handled the call. KCBS wanted an expert to speak on the air about the possible health hazards from the radioactive plume then heading towards the West Coast. Stephenson arranged for KCBS to interview Marvin Dickerson, a Livermore atmospheric physicist who was tracking the plume and collecting meteorological data for DOE.

"Dickerson compared the low levels of radiation from the Chernobyl cloud with the normal background radiation of about 150 millirems per year and reassured the listening audience," Stephenson says.

The KCBS request was followed by dozens of other media calls. Stephenson and her counterparts at Livermore and other national labs, were kept busy providing appropriate scientists for each journalist—until the DOE gag order came on the afternoon of Tuesday, April 29.

C. Anson Franklin, DOE director of communications, denies there ever was any gag order. He says that DOE employees around the country were simply "encouraged to avoid speculation but, of course, could respond to questions of fact."

That's not the way Stephenson remembers it. "I'll probably get into trouble for saying this, but I sure didn't have it expressed to me that way," she says. "At 1:30 P.M. Tuesday, I was told in no uncertain terms to stop talking to reporters and to stop my people from talking to reporters." Another public-information officer at Livermore confirmed Stephenson's story. The officer, who was unwilling to let his name be used, complained that he and his co-workers had been put in a double bind: DOE had told them not to comment, yet when journalists called the DOE in Washington, officials there were referring them to Lawrence Livermore.

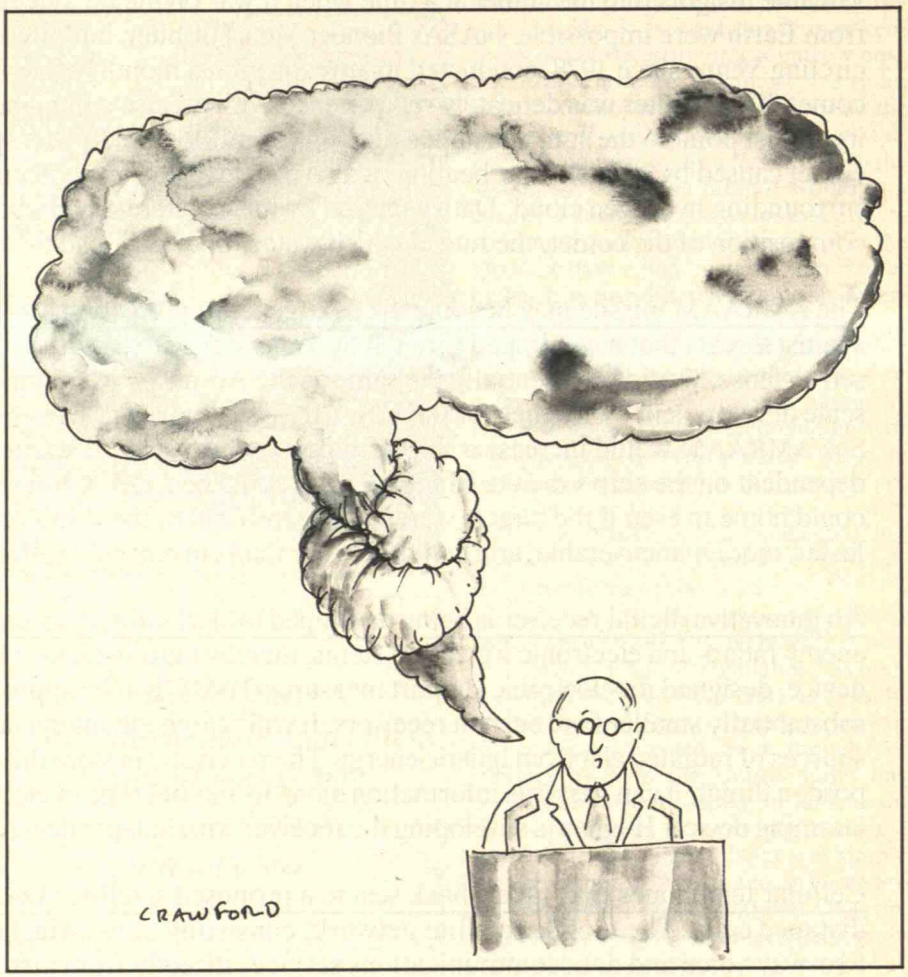


ILLUSTRATION: MICHAEL CRAWFORD

FRED JEROME is director of the Media Resource Service, which puts journalists in touch with scientists who have agreed to answer media questions in their areas of expertise. The Service is run by the Scientists' Institute for Public Information.

In fact, in the May 22 *New York Times*, Stuart Diamond reported that four separate government gag orders were issued the week after the accident—two by DOE, one by NRC, and one by the Department of Agriculture. According to Diamond, one DOE memo said that to "curtail possible misinformation," department employees and contractors were "advised to avoid commenting on the situation in Russia." They were similarly advised "to avoid making comparison" between American reactors and Russian ones.

At the Media Resource Service, we had little doubt that a gag order had been issued. On Tuesday afternoon, the same national lab scientists who had initially been so cooperative suddenly told us they had received orders from the DOE or NRC not to speak to the press. If the order allowed scientists to "respond to questions of fact," you couldn't have proved it from our experience.

A case in point is a story Cable News Network was doing. The network had decided to cover the Geiger-counter tests being conducted at JFK airport on the American tour group returning from Kiev. Reporters called MRS looking for a scientist who could show the Cable News audience how such tests are performed. We contacted Brookhaven Labs, but they said DOE orders prohibited them from any contact with the press. Yet Brookhaven scientists were the ones conducting the tests!

In another instance, a reporter from the Tennessee *Oak Ridger* called to ask if we could refer him to an expert who could provide a simple, factual definition of melt-down. We suggested that he contact the Oak Ridge National Lab. "I've already tried them, but they say they're under orders not to talk," the reporter explained.

The Oak Ridge clam-up prompted Dick Smyser to eloquent protest. Smyser, editor of the *Oak Ridger* for the last 37 years and past president of the American Society of Newspaper Editors, is an easy-going newsman who has long supported DOE's efforts to develop nuclear energy. But when the DOE gag order came down, the mild-mannered Smyser came out swinging words of steel. He declared in his May 6 editor's column, "I do not recall ever before a bureaucratic fiat telling several thousand scientists and engineers that they could not comment on a world event." Smyser called the DOE action a "deceptive and misinformative business," and "frightening."

Making Political Hay

Was the gag order simply bureaucratic bungling? Or was it something more ominous—part of an emerging administration policy to restrict the release of information during times of crisis?

The bureaucratic-bungling theory holds that DOE did not intend to cut off comment—just to discourage scientists who might have been tempted to engage in wild speculation about the cause and/or effects of Chernobyl. But as the order was passed down through the ranks each new level of bureaucracts added a few more restrictions to be on the safe side. For example, while DOE's Franklin, insists that the department "never attempted to curtail information," he says "there probably was some misunderstanding in the transmission" of the order.

But if the Administration really wanted to curtail speculation, why didn't they curtail Kenneth Adelman, director of the Arms Control Disarmament Agency (ACDA)? On the same day of the DOE gag order, Adelman, who has no particular nuclear expertise, testified before a Senate subcommitee. He said the Soviets' claim that two people had died from the initial explosion and fire was "preposterous." He announced that the Chernobyl fire "will continue for several days" and that nothing could be done other than to "let it die down." He said the fire was burning "at a fantastic temperature" that posed a continuing threat of further explosions and contamination.

Finally, if the government was so intent on ensuring accuracy, why didn't the White House release information from the high-resolution spy-satellite photographs taken of Chernobyl right after the accident? Such photos would have clearly indicated the extent of damage to the reactors and the effect of the accident on the people nearby. We certainly could have alleviated some anxiety by informing the Europeans that because the Chernobyl fires were out, the contamination they were receiving had probably peaked.

The Reagan administration says that releasing those photos would have compromised important intelligence information. However, Stansfield Turner, former director of the CIA, has noted that the photos

themselves wouldn't have had to be released—only a description of what they revealed. In an article for the *New York Times*, Turner wrote that this would not have jeopardized sensitive intelligence sources. He went on to say that the benefits of disclosing information sometimes outweighs the risk of sharing secrets. It's hard to avoid the conclusion that at least some elements within the administration were eager to make political capital out of the Chernobyl tragedy. Such officials probably welcomed speculation that magnified the consequences of the accident. (According to the *Washington Post* of April 30, one administration supporter in the Senate, Republican Steve Symms of Idaho, said, "It's too bad it didn't happen closer to the Kremlin.")

In any case, far from curtailing speculation, the DOE order encouraged it. Stephenson says that when she told reporters about the no-comment policy, one common response was "Holy _____!" That radiation cloud must really be bad, and headed this way. That's why they won't tell us anything."

As Smyser points out, what the gag order did was "inhibit the most informed speculation and leave a void to be filled by the less informed and uninformed." Smyser also suggests that it's likely that "the DOE got its orders from some place higher up, maybe even the White House." Supporting this idea, Diamond reports in the *Times* that one government official, "who spoke on condition of not being identified, said that the press curbs had been ordered by the White House."

Wherever it originated, the Chernobyl gag order does seem to reflect a pattern; more and more, U.S. government officials are restricting information. Remember the much-ballyhooed "spy dust" story last August, when the State Department said the Russians were "tracking" U.S. embassy personnel in Moscow with a chemical substance that might cause cancer? Subsequent investigation showed little if any risk to anyone, except possibly the Soviet cops who might have been spraying the stuff. But at the time, the government's charges made page-one headlines in every paper in the country. In an effort to find out about the little-known chemical (NPPD), Lee Koromvokis of the MacNeil-Lehrer NewsHour called Ernest McConnell of the National Institute of Environmental Health and Safety (NIEHS). Koromvokis reports that her phone call was interrupted by a State Department representative with orders that no one at NIEHS was to talk to reporters and that all press queries were to be referred to the State Department.

After the space shuttle Challenger blew up, the government did it again. The previously affable NASA officials suddenly turned silent, and the news media were forced to turn to outside sources for information about what had gone wrong. NASA has never acknowledged instituting a gag rule. But NASA general manager Philip Culbertson recently told radio and television news directors in Washington, D.C., that he wanted to "apologize to a degree for NASA's apparent non-responsiveness during that period."

At the American Association for the Advancement of Science (AAAS) annual meeting in late May, Hugh Harris, NASA's public-relations director at Cape Canaveral, told a roomful of journalists that all NASA officials are free to talk to the press if they do so for the record. Yet only weeks later, NASA refused to allow one of its astronauts to go on the MacNeil-Lehrer program and discuss the Rogers Commission report. The only result of NASA's ostrich act, predictably, has been a lot of sand in the agency's face.

In a democracy, government gag orders don't curtail media coverage. Instead, they cause the press and the public to wonder what those who gave the orders are trying to hide.

Futhermore, in issuing the Chernobyl gag order, the administration missed the boat—and what a boat it was. If ever an opportunity existed to contrast our open public communication with Soviet secrecy, Chernobyl was it.

By now, someone in our government surely must have realized that in times of crisis, it's best to give the media more information—not less. □

BY JAMES J. MacKENZIE

Lower Oil Prices Fuel Concern

THE dramatic drop in world crude oil prices has provided welcome relief for consumers. But ultimately it could cause distress. That's because any related increase in consumption—which is very likely should prices stay low for several years—would hasten depletion of the world's finite amount of oil. Production could be forced to decline as early as the next decade.

This means that the need to increase fuel efficiency and develop and deploy new energy sources remains urgent. Except for its interest in nuclear fission and the Strategic Petroleum Reserve, the Reagan administration has adopted a policy of benign neglect on the energy issue. Research has been drastically cut in the belief that the market alone will solve our problems. Unfortunately, the failure to take a long-term perspective promises that the United States will be ill-prepared to deal with the inevitable transition from oil.

JAMES J. MacKENZIE has recently joined the World Resources Institute in Washington, D.C., as a senior associate. He wrote this article while he was a senior staff scientist at the Washington office of the Union of Concerned Scientists.

Today's low oil prices may only deplete the world's reserves faster.

Despite the view of the U.S. government, the past decade has seen a growing recognition among petroleum companies and analysts that the end of the oil era is approaching. In 1982, an Exxon Corp. report on oil and gas resources stated that steady or slightly increased oil consumption would probably mean that production would reach a plateau early in the next century. The same year, Richard Nehring, a Rand Corp. analyst who has completed major reviews of global oil resources for the CIA, wrote that world petroleum production would likely "decline by the early decades of the twenty-first century."

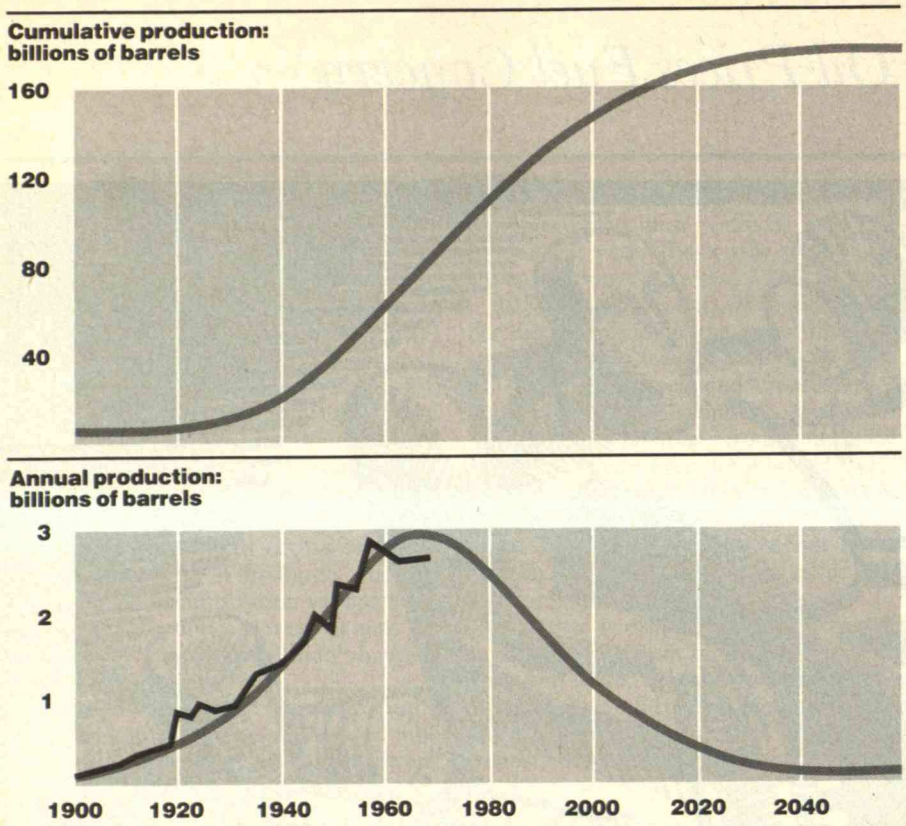
The oil price drop cannot make these forecasts rosier. After all, the decline from almost $40 per barrel in 1982 to about $15 last May was not caused by an increase in the total amount of oil that ultimately can be produced, but by reduced demand and a production increase from non-OPEC producers. Most OPEC members have also produced more than their quotas, adding to the glut.

How Much Oil on the Earth?

Geologists have made many estimates of how much crude oil can ultimately be recovered. Estimates made since the late 1970s range from 1,600 to 2,400 billion barrels. As of 1985, the location of about 1,200 billion barrels of the oil had been discovered, including about 550 billion that had been consumed. That would leave 400 to 1,200 billion barrels still to be found. Most of the undiscovered oil is probably in the Middle East, despite smaller recent finds in the North Sea, Mexico, and elsewhere. Geologists do not expect that new oil finds will change the long-term estimates.

There actually could be less recoverable crude oil than these estimates predict, ac-

ILLUSTRATION: ANTHONY RUSSO



In 1962, M. King Hubbert used a logistic curve (top) and a corresponding bell curve (bottom) to predict that U.S. continental crude oil production would soon peak. Similar curves show world output could peak between the 1990s and 2035.

cording to techniques developed by M. King Hubbert, a retired U.S. Geological Survey scientist who pioneered the application of mathematical physics to geologic problems. For almost 40 years, Hubbert has analyzed data on the size of past oil discoveries and the amount of production in the continental United States to predict trends. His estimates factor in how quickly supplies are being used. To understand why his approach should apply globally, consider how it works and its success:

According to Hubbert, the data for cumulative crude oil discoveries and production can be closely fit with a simple mathematical function called the logistic curve. This s-shaped curve is derived from a bell curve that indicates annual production values at each point. The bell curve starts at zero, rises for a period of years to the maximum production level, and then falls off to zero. A logistic curve, which indicates the total amount of oil that will ever be discovered, rises and then flattens as it approaches this value.

In 1962, Hubbert plotted a logistic curve on a graph using the data for U.S. cumulative crude oil production. He predicted that production would peak in 1967, and it came in 1970—not far off the mark considering the total number of years that oil was expected to be produced. Today, with the aid of a computer, the logistic curve predicts that the total amount of crude oil that can ever be recovered in the continental United States is 190 billion barrels. It also indicates that by the year 2004 the country will have consumed 90 percent of this oil if production continues to follow the logistic curve.

Even with aggressive exploration sparked by the 10-fold price increase in the 1970s and early 1980s, domestic production has declined as Hubbert predicted it would.

That suggests that logistic curves can produce valid estimates worldwide, although far fewer discovery and production data are available for the rest of the world. Fitting a logistic curve to the total global discoveries so far yields a value of 1,450 billion barrels of ultimately recoverable crude oil. This number is obviously below the range of recent estimates. It probably would be higher if global oil production during the past 10 years had not been depressed by the high prices set by the OPEC cartel. To compensate, production data can be increased to levels that probably would have occurred under free-market conditions. Doing so suggests that there is a total of about 1,500 billion barrels worldwide—still below other recent estimates.

A variety of possible cycles for global crude oil production can also be calculated using logistic curves. If global consumption stays the same as it is now—and if there is a total of 1,500 billion barrels of recoverable crude oil—production will have to decline in about the year 2010. If all the estimates of total recoverable oil are low, and as much as 2,500 billion barrels can be recovered, production will start to decline in about 2035.

But what if lower crude oil prices result in more petroleum consumption worldwide? Then production will peak in the 1990s, assuming that there is a total of 1,500 billion barrels of recoverable crude oil. Even if there are 2,500 billion barrels of recoverable oil, the estimate moves up just slightly to a few years after the turn of the century.

Consumption Could Rise

Constraining global oil use obviously postpones the inevitable downward trend considerably and gives the world more time to develop alternative fuel sources. But global consumption is very likely to rise if oil prices stay at or below present levels through this decade. That's because oil is the cleanest, most convenient energy source. The biggest increase in oil use could occur in the developing countries and the Eastern bloc. Developing countries will probably consume more oil if prices stay low because they have little of the infrastructure needed to supply natural gas or electricity. Plus, the principal source of energy in many of these countries, wood, is being depleted rapidly. Meanwhile, the Soviet Union increased its petroleum consumption each year from 1973 to 1984, even as the West reduced its use.

Oil is attractive to the industrialized nations because it can be burned with very little pollution or other environmental side effects. While the use of more fuel-efficient heating systems and automobiles during the past decade should help matters, gasoline use will increase in the United States if people start driving more miles. That is already happening. According to the June 2, 1986, issue of *Business Week*, gas consumption had risen at an annual rate of 2.6 percent since the beginning of the year, compared with 1.8 percent growth in 1985. The United States, which consumes 25 percent of the world's oil, uses 62 percent of that amount for transportation.

Though markets will eventually adjust to declining oil supplies, prudence dictates anticipating the problem before the decline begins. Regrettably, there are few options. In the short term, an international

DIAGRAM: OMNIGRAPHICS

effort must be mounted to increase energy productivity in both industrialized and developing countries. Making vehicles, houses, and industrial plants more fuel efficient would provide two to three decades of breathing room. The industrialized nations should promote this by instituting minimal efficiency standards for major energy-consuming equipment and adopting additional oil taxes. An increase in the U.S. gasoline tax would provide an incentive for consumers to puchase more energy-efficient cars. Financial and technical assistance to developing countries should focus on introducing only the most fuel-efficient technologies to avoid repeating the mistakes of the industrialized nations.

Switching to Other Fuels

In the long run, a switch to other fuels will be required. Research programs should be stepped up to accelerate the transition. Unfortunately, each of the major fuel sources that could supplant conventional oil poses problems. Coal, oil shales, and tar sands can provide plenty of energy, but their use exacerbates the risks of climate change from the buildup of carbon dioxide in the atmosphere. A massive shift to carbon-based synthetic fuels should therefore be avoided. Nuclear power issues—safety, waste disposal, and the possibility of nuclear fuel playing a role in the spread of nuclear weapons—continue to be debated. The Chernobyl accident will almost certainly slow, if not halt, the construction of more nuclear plants, at least in the West. Renewable resources, such as solar energy and wind energy, present problems because they are intermittent sources of electricity.

It is especially important to develop alternative energy sources for transportation. Hydrogen and electricity are two options to replace petroleum in vehicles, and there may be others. Expanded research in energy storage is badly needed.

The Reagan administration should focus more on these concerns if only because of the declining oil production levels in the lower 48 states. The nation is increasingly dependent on imports. Last year the United States imported 27 percent of its oil, but in 1988 it is expected to import almost half its supply. And while just a small proportion of today's imports come from the Mideast, all future additional imports will probably come from that politically unstable region. □

THUROW

CONTINUED FROM PAGE 22

A few numbers illustrate the problem. Maintaining an American standard of living now requires a $20,000 investment in housing for each new human being. Each person will have to be fed for 20 years before starting to work and feed him or herself. This will require another $20,000 at the very least. Giving that human being an average American education will require $100,000. Providing the plant and equipment that he or she will need at work will require another $80,000. And providing transportation for that human being will mean yet an additional $20,000. Roughly speaking, each new human being will need an investment of about $240,000 before he or she is capable of fitting into the American economy as a self-sufficient worker.

If the United States had a 4 percent population growth rate, one-half of its entire GNP would have to be devoted to investing in those new Americans. Adult Americans would have to take a sharp cut in their present standard of living. Americans probably wouldn't be willing to make the necessary sacrifices—just as the wealthy people in those countries with rapid population growth rates haven't been willing to make the personal sacrifices that would make rapid population growth and economic development consistent. The result: continued poverty in those nations with high rates of population growth.

And to the extent that new technology is invented, it will probably require more investment in new plant and equipment and new skills, and make the "start-up" costs of a new worker even higher. Improved technology doesn't solve the population growth problem in the short-run.

In the end, economic analysis tells us little about the ultimate population that the world can sustain. But it reveals a great deal about the speed with which the world can get to that ultimate limit. If a given country desires economic development, then its population growth cannot increase by more than 2 percent—half the rate of population growth now being experienced in most of the underdeveloped world. □

NASA's history of pursuing costly dead-end programs to ensure its own survival has undermined any attempts to develop long-term goals in space.

Getting Back on Track in SPACE

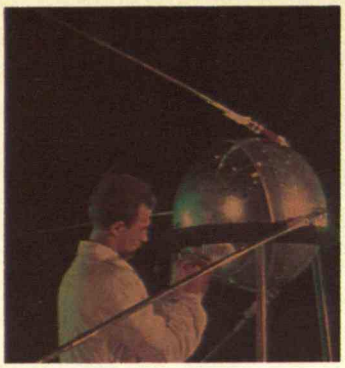
VISIONARIES and schoolchildren stood at the threshold of the 1960s with joy and anticipation: humankind was finally beginning the conquest of space. Any reasonable extrapolation of the events of those early years—the first artificial satellite, the first human in space, the first planetary probe, the first space walk, the race to the Moon—would show humanity firmly established in space within the extrapolator's lifetime. By the end of the century, there would certainly be space stations, space colonies, trips to the planets, perhaps even vacations in space. It was heady stuff.

Today, few if any of these dreams appear to be forthcoming. Partly this is due to overblown expectations. But it is also the result of some strange decisions that have been made since the early 1960s, including the race to the Moon and the building of the space shuttle. The space community has become obsessed with these expensive programs, even though they have not been dedicated to meeting any clearly defined long-term goals. Moreover, these programs have superseded a long list of other space accomplishments. Even now, when we have enough information to reverse some of the damage, we seem to be perpetuating the same mistakes. The decision has just been made to replace *Challenger* with another shuttle, at a cost of $2.7 billion. Yet the evidence at hand suggests that these funds could be better spent on reestablishing unmanned U.S. launch capabilities, and on exploring the possibility of using space-based materials such as hydrogen, oxygen, and minerals for future space activities.

In the meantime, the Soviets have gained a lead in manned space flight. The United States has shown itself to be the "hare" in the space race, while the Soviet Union is reaping the rewards of being the "tortoise." If we want to maintain our leadership in space, the United States must develop and stick to some clearly defined long-term goals. Yet before we decide what should be done between now and the end of the

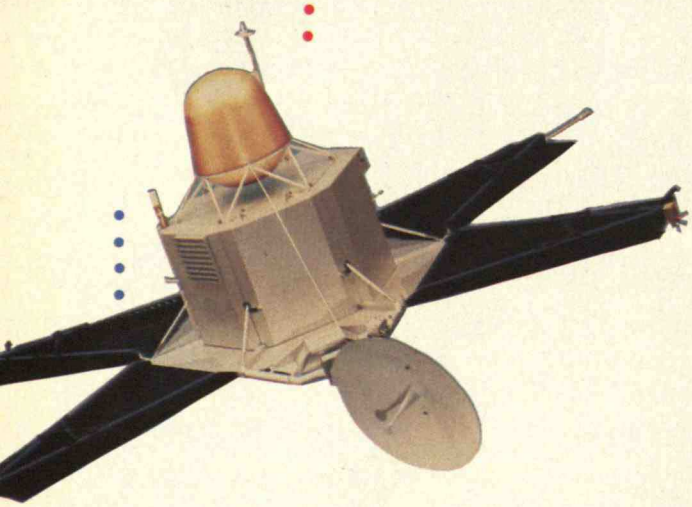
BY RUTH A. LEWIS AND JOHN S. LEWIS


USA



1957. World attention turned to space when the Soviet Union launched *Sputnik I*, the world's first artificial satellite. The launch triggered the race in space between the two superpowers.

1961. The Russians leaped ahead by sending the first human into space. Yuri Gagarin orbited the Earth in *Vostok 1*, a spherical 10,400-pound spacecraft.



1962. The U.S. scored a major space first by launching *Mariner 2*, the first successful planetary probe. It passed within 22,000 miles of Venus and sent back valuable data on the planet and previously unexplored regions of space.

century, we must understand how the space program evolved. The legacy of decisions made in the 1960s and 1970s still haunts us today.

The overriding feature of the earliest days of the space age was the competition between the Soviet Union and the United States. No one older than ten in 1957 can forget the shock that Americans felt when those first headlines appeared announcing that the Russians had put a satellite into space, which orbited above our heads every 90 minutes or so. The cry of what was wrong with America, with our educational system, with our scientists, with our technology, could be heard everywhere.

The United States harnessed its formidable technological might to the task of overtaking the Soviets. However, other Soviet challenges, such as the first Soviet lunar and planetary probes (1959-60) and the first humans in space (beginning with Yuri Gagarin's one-day flight in 1961), were launched with so little advance notice that the United States had difficulty responding in time. The Soviets had the advantage of a huge rocket for putting spacecraft into orbit. The Soviets had developed this booster for launching intercontinental ballistic missiles in the 1950s because they did not have good guidance systems or hydrogen warheads. The booster enabled them to deliver very large, heavy atomic (fission) warheads to compensate for their limited accuracy. In contrast, Americans, having developed lighter and very powerful hydrogen (fusion) warheads and better guidance systems, were content to design much smaller boosters. Thus the initial American attempts to put a payload in orbit were puny by comparison with the Sputniks. The Soviets registered one first after another in those first seven years of the space age, and U.S. frustrations mounted.

The Apollo Dead-End

Then came Kennedy's bold challenge to race the Soviet Union to the Moon, despite the commanding Soviet lead in almost every area of space technology. The Soviet Union was in a position to beat the United States to the Moon. The Soviet program consisted of two parts—the first to fly people around the Moon and return them safely to Earth, and the second to land people on the Moon. Russian hopes were pinned squarely on circumnavigating the Moon because a series of failures with a new huge third-

PHOTOS: NASA; SOVPHOTO; AP/WIDEWORLD

generation superbooster had left them seriously behind in lifting a payload large enough to land there. The new superbooster exploded three times in three launch attempts and never flew successfully. The Soviets' second-generation booster was powerful enough to allow them to circumnavigate the Moon, but no more.

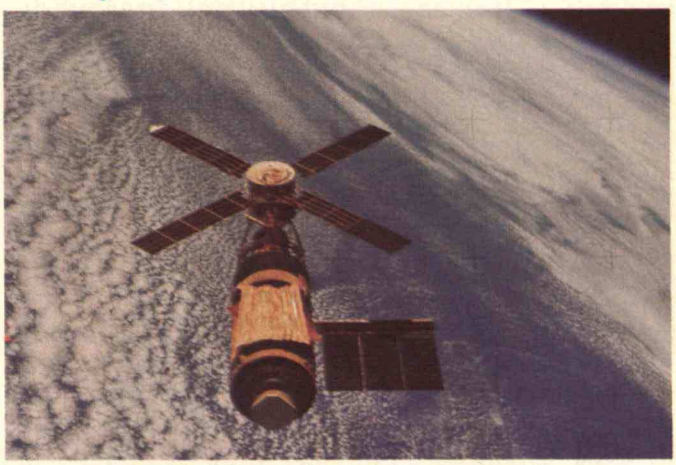
At the same time, Apollo 8—the mission to orbit three American astronauts around the Moon and bring them back—was running ahead of schedule. The mission was successfully completed several months earlier than originally planned, scooping the Soviet circumlunar attempt. Rather than come in second, the Soviet Union canceled its mission. After further delays with their superbooster, the Soviets also canceled their entire manned landing program. Neil Armstrong and Buzz Aldrin landed on the Moon uncontested—five months before the end of the decade.

Since then, the Soviets have never gone to the Moon. They couldn't face being second-best: they even denied for several years that they had intended to send people there. Also, Soviet Premiers Brezhnev and Kosygin consciously rejected the space spectaculars and missile-rattling bombast of the Khrushchev era. The Soviets turned their energy to the quiet pursuit of long-term goals—and they ceased engaging in public races with the United States.

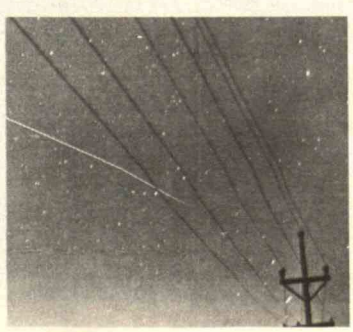
Meanwhile, in 1972, the United States finished its abbreviated series of Apollo lunar landings successfully. While the American public waited for the next space triumph, the nation's decision makers bogged down in debate about what the next step should be. In fact, as Americans later discovered, Kennedy had planned Apollo as a dead-end: it had served its political purpose of giving the United States a national goal and building its international prestige. According to space policy analyst John Logsdon in *The Decision to Go to the Moon*, one of Apollo's strongest attributes from Kennedy's point of view was that it would require no long-term national commitment to further space endeavors.

So the United States was left without a long-term goal in space, and NASA's very existence became threatened. With the follow-up Apollo-applications program cancelled for lack of funds, NASA knew it had better find some new project of sufficient size, cost, and duration to assure its own future. So NASA officials decided to repeat the Apollo method: they

1969. The U.S. *Eagle* landed the first human on the Moon uncontested. The Soviets canceled their entire manned-Moon-landing program when delays with their superbooster made it clear that they would come in second.

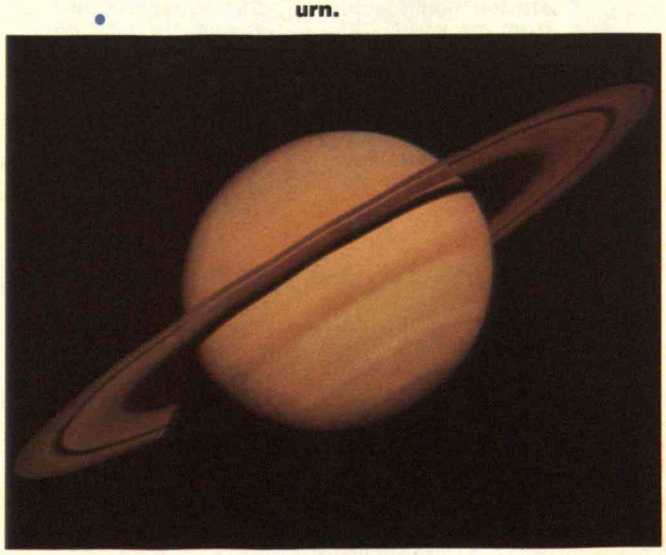


1973. The U.S. *Skylab,* an early space station, had trouble from the start. Its meteoroid shield ripped off during launch, leaving the vehicle without protection against the sun and particles that might puncture its walls. After a year of manned operations, *Skylab* was abandoned. Its orbit decayed, and the $3 billion station burned up while entering the atmosphere in January 1979. Its only trace was a streak in the sky (below).



1975. The Apollo-Soyuz Test Project entailed a complicated docking between the *Apollo 18* and *Soyuz 19* spacecrafts. This was the first of only two joint U.S.-Soviet space projects.

1977. A series of successful U.S. planetary probes yielded breathtaking photographs and valuable scientific data. At left, the *Viking Orbiter 2* photographed this martian dust storm. Below, *Voyager 1* sent this dramatic shot back to Earth while passing 11 million miles from Saturn.



looked for a costly, long-term program that would appeal to the hearts of the American people, and hence to congressional decision makers.

NASA first mentioned the idea of developing a reusable spacecraft around 1970, when environmental concerns were at their peak. The concept of saving millions of wasted dollars by reusing a launcher's components—including the boosters that fell into the ocean every time a satellite went into space, the fuel tanks, and the orbiter itself—would certainly appeal to the American public. But as Logsdon and others have noted, what was most appealing to NASA was the prospect that such a vehicle would take many years and a vast number of dollars to develop. It would assure NASA's survival.

Two concepts lay behind NASA's proposal to develop a reusable space shuttle for routine transportation into space: that humanity belonged in space, and that a permanent space station was the "next logical step" to putting the species there permanently. With little internal debate, NASA accepted the concept that the space station would be serviced and restaffed by the shuttle, which would have payload costs low enough to make this sort of activity affordable.

Once NASA had placed itself squarely behind the shuttle concept, it had to gain the support of the many federal agencies that would assure its continued survival. NASA decided it would need the support of the Department of Defense (DOD) to win White House and congressional approval. As a result, low development costs were almost immediately sacrificed so that the shuttle could incorporate specifications the military felt were important. For instance, the air force wanted a spacecraft that could return quickly from orbit and maneuver easily under threatening conditions.

In the end, a compromise shuttle was funded. Although President Nixon approved the program, he did not follow up with continuing support. (*See "Tough Choices Ahead for NASA," page 21.*) As a result, funding dwindled, further compromising the shuttle's design. In fact, the notion of reusing most of the shuttle components was sacrificed to keep down development costs. A number of elements in the final design emphasized low initial costs at the expense of higher operating costs—a price we are still paying today. For example, the external fuel tank, which now carries both hydrogen and oxygen outside the shuttle, was originally designed to be inside a recoverable stage of the rocket.

Some scientists feared the shuttle would be a hideously expensive toy.

Feeding the Hungry Giant

The era of putting all our space eggs into one basket began with the shuttle program. To avoid the risk that Congress might fund some other booster instead, NASA scrapped all its other boosters long before the shuttle was available. The Saturn 1 and Saturn 5 boosters, which had cost about $15 billion to develop for the Apollo program, were put into mothballs. (An intact Saturn 5, all 365 feet of it, which cost the American public $200 million, sits rusting outside of Johnson Spaceflight Center in Houston, a vivid testimonial to what we used to be able to do in space.)

However, the shuttle program suffered repeated delays because of inadequate funding and continuing problems with its main engines and heat-shield tiles. When the shuttle seriously overran its budget, NASA fed the hungry giant by scrapping a long series of valuable, inexpensive research programs. The solar-system exploration program, which had averaged two new mission starts per year, was cut dead for six consecutive years. Advanced propulsion research was sliced to the bones. *Skylab*, a preliminary version of a U.S. space station that was begun during the Apollo era, was abandoned. This $3 billion vehicle was a huge empty shell launched by a Saturn 5 superbooster in 1973. A few days later, three astronauts launched on a Saturn 1 docked with *Skylab* and remained inside for a month. Later that year, two other sets of astronauts paid visits of two months and 84 days. After that, no more flights of *Skylab* astronauts were scheduled, so the shell itself, the largest Earth-orbiting satellite ever to be launched, was left to circle the globe empty and alone. A technology already developed and paid for was sacrificed for a new and untried program.

This is doubly ironic because one original purpose of the shuttle was to ferry astronauts back and forth between the Earth and a space station. Since *Skylab*, the first version of such a permanent facility, had been abandoned, what was the shuttle supposed to shuttle to?

One of the first official tasks of the new shuttle vehicle was to visit *Skylab* and keep it functioning. But because the shuttle ran years behind schedule, *Skylab* died unaided. And because the disposable Apollo boosters had been scrapped, there was no alternative method of reaching the satellite. Without refueling from Earth, *Skylab*'s orbit decayed and, in 1979, the craft burned up in the atmosphere.

In selling the shuttle to Congress, NASA had said a fleet of five orbiters would be operating by the end of the 1970s, with one launch of each orbiter scheduled every month. But what would be the purpose of these launches?

NASA claimed that the shuttle would mainly be used to do space science. But scientists had been excluded from planning the shuttle. A number of scientists were in fact deeply concerned that the shuttle would be a hideously expensive toy, poorly suited to launching unmanned scientific payloads into interplanetary space.

(NASA was recently forced for safety reasons to cancel the shuttle mission that was to carry the long-awaited Jupiter-Galileo probe into orbit later this year. Some scientists, notably James Van Allen, professor of physics at University of Iowa and discoverer of the Earth's radiation belts, had argued that this sophisticated probe could be launched more easily by an expendable unmanned rocket. But since NASA had scrapped all such expendable rockets, the agency instead spent $700 million to retrofit the shuttle for this mission. That money has essentially been wasted with the cancellation of this launch.)

Why the Shuttle Costs So Much

Despite scientific opposition the shuttle was built—at a cost of nearly $11 billion, double NASA's original estimate of $5 billion to $6 billion. From the target launch date of 1977, the shuttle slipped to a first flight in April 1981. The estimated costs of launching payloads on the shuttle rose from $100 (in 1986 dollars) in the mid-1960s to $275 per pound in the mid-1970s to about $4,000 per pound today. Operating the shuttle costs about $3 billion a year whether it is actually used or not. Crews, teams, and facilities must be kept ready. From an original five shuttles that were to fly a total of 60 flights a year, we now have three shuttles that are scheduled to fly four times a year each, for a total of 12 flights a year. The base cost has risen from $50 million per launch to $250 million.

Why does the shuttle cost so much? One of the main reasons concerns its most significant design feature: it must be operated with human beings on board. The life-support and safety features necessary to make a spacecraft safe weigh a great deal. And since lifting shuttle payloads into space costs about $4,000 per pound, weight is a critical ingredient. It costs more than half a million dollars to lift one

NASA, with a budget 2 percent that of the Defense Department, has built and paid for DOD's top launch vehicle.

astronaut (not including food or gear).

If scientific experimentation or manufacturing that required human input were the primary purpose of the shuttle, then perhaps these costs would be justified. But right now the shuttle is mostly used to launch unmanned satellites. This task can easily be done automatically from an expendable unmanned rocket, as done in the pre-shuttle era—and as European Space Administration, the Soviet Union, the USSR, China, Japan, and India now do in actively competing with the shuttle.

Reusability, too, has its costs. First, the shuttle's solid-fuel rocket boosters sustain much more damage when they hit the ocean than their designers had originally expected. Next, the orbiter itself, with its myriad custom-fitted reentry tiles and the need to ferry it between the two sites (a launching and landing pad) in different parts of the country atop a custom-fitted 747, costs more to transport and refurbish than once thought. And last, NASA's steadfast insistence on throwing away the external tank—which could be carried into orbit to good advantage—wastes more precious resources. The external tank contains enough residual fuel to launch payloads from the shuttle's low-Earth orbit to high-Earth orbit, and even to the Moon. The shell of the tank could also be used as a component in a space station. Allowing the tank to fall back to Earth and burn up costs more than carrying it into orbit. Why NASA won't change its policy remains a mystery.

Vagaries of the U.S. Budget Cycle

NASA's budgetary difficulties are not entirely its own fault. The vagaries of the one-year American budget cycle as managed by Congress have a lot to do with the success or failure of a program like the shuttle. If NASA could be assured of its continuing existence, it might not feel pressured to undertake huge meaningless programs. The actual NASA budget in constant 1985 dollars diminished from a high in 1964 of almost $19 billion to a low in 1978 of about $5 billion. The 1986 budget was $7 billion.

The present funding level is slowly killing NASA. Essentially, Congress has willed NASA enough money to keep its basic operation and physical plant intact, but is reluctant to spend more to develop scientific payloads for launch.

According to its charter, NASA is supposed to be a research and development agency. Yet because there has been little money for scientific payloads, NASA has largely turned to commercial and military payloads to subsidize the cost of the shuttle.

Because it is now in the commercial launch business, NASA is in direct competition with private enterprises. And because shuttle payloads cost so much, NASA has to subsidize the cost of launching private payloads to attract business. The agency charges users only about $1,400 per pound, leaving a subsidy of $2,600 per pound to be paid by American taxpayers. Therefore, even if an efficient private company could get costs down to $2,000 or $1,500 per pound, it still could not compete. The government is essentially sabotaging the free-enterprise system with all its potential for enhanced efficiency and economy.

Something should be said about the role of the military in all this. Although many Americans resented the secret military shuttle launch of 1985, several other shuttle flights have included military payloads. In fact, 20 to 25 percent of all shuttle payloads have been military. According to NASA, when the shuttle becomes operational again, the number will be more like 35 percent.

The Pentagon has certainly benefited from having the subsidized shuttle available, since it has increased the defense budget without appearing to do so, and since the Defense Department paid nothing to develop the shuttle. NASA, with a budget that is about 2 percent of DOD's, has subsidized DOD's top launch vehicle.

Space Station Boondoggle?

Many people have hoped that NASA would learn from its mistakes with the shuttle, but it seems likely to repeat them with the space station. Much like the shuttle, the multi-billion-dollar space station is a poorly conceived piece of hardware being sold as something it cannot be. NASA promoted the space station as a superb platform for doing space science.

In the early 1980s, the Space Science Board, the organization that recommends what NASA should do in the space sciences, met with space station program manager John Hodge to find out what NASA had in mind for the station. NASA had agreed to the meeting only on the condition that the agency would tell the board what the station would do for science—instead of finding out what the board thought the space station could do.

The present funding level is slowly killing NASA.

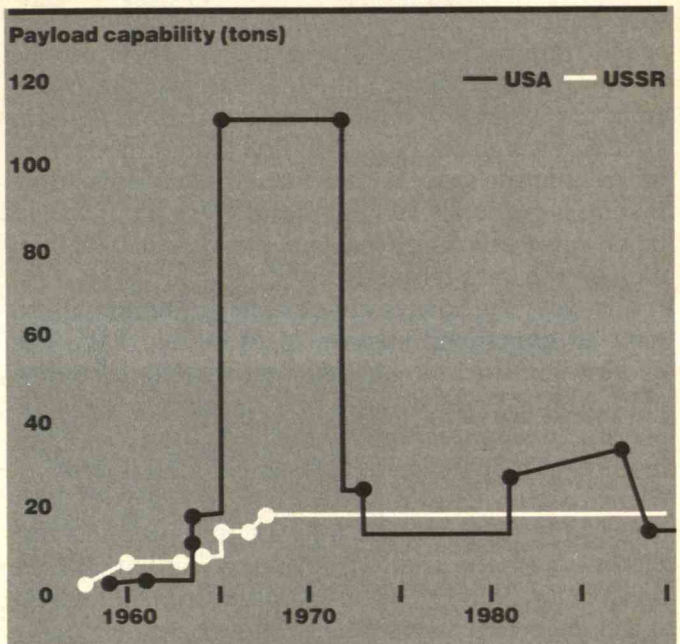
The meeting shocked the board members. The roles that NASA proposed for the space station had no relation to the goals of space scientists. For example, experience with other spacecraft had shown that any human motion—even respiration and heartbeat—is enough to cause vibrations that can disturb delicate instrumentation. Similar problems would arise in electromagnetic interference from the vast variety of instruments and equipment necessary to monitor the people aboard the space station. Furthermore, emissions of gases and particles from such a large manned structure would pose a severe problem for many sensitive scientific experiments. NASA was, in effect, ignoring years of experience gained on previous missions.

The Space Science Board sent a memo to NASA voicing its concern and stating that the space station would not be a good place to do space science at all. The board estimated that 80 percent of the science tasks envisioned by NASA planners would be severely compromised or impossible on the space station, 10 percent would be complex enough and forgiving enough to profit from being done there, and 10 percent were "don't cares"—it didn't matter whether those experiments were conducted on a manned or unmanned station. The members were thus astonished to hear NASA officials testifying a few days later to Congress that the United States needed a space station to be able to do space science better. Again despite initial scientific opposition, plans for the space station are moving ahead, with the structure planned to be operational in the mid-1990s.

The Soviet "Tortoise"

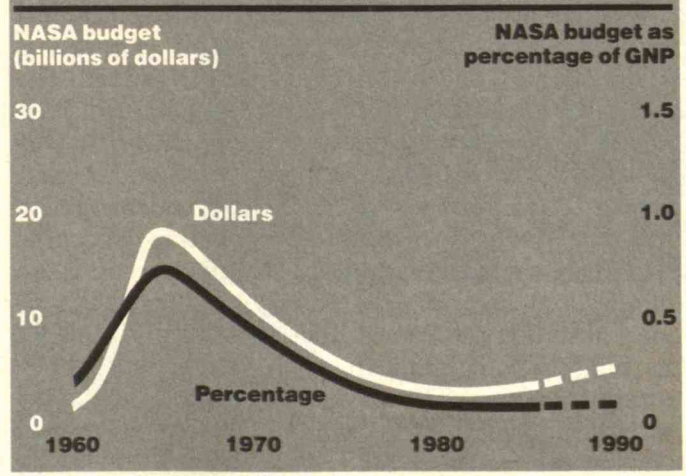
The Soviet Union, meanwhile, has gone its own way into space. With the launch of the first Salyut space station in 1971, the Soviets recaptured the lead in manned space flight they lost to the United States during the Apollo era. Salyut is a small space station in Earth orbit (about a quarter the size of *Skylab*) that can be resupplied using smaller docking craft. Today the Soviet Union has a tremendous lead in astronaut-days in space: 75 percent of all manned experience in space belongs to the Soviet Union. Soviet cosmonauts have stayed aboard the Salyuts for as long as eight months at a time, while no American has ever been in space as long as three months.

Because the Soviets have provided steady funding,



The demise of the Apollo program in the mid-70s—and the mothballing of NASA's Saturn rocket booster—brought a rapid decline in the U.S. ability to carry heavy payloads into space. The explosions of the space shuttle *Challenger* and the Titan 34D booster this spring again returned the U.S. to its 1963 level of lifting power. The Soviets, however, will be capable of orbiting 100-ton payloads by 1987.

The chart below illustrates the rise and fall of the NASA budget. The gray line shows its size in billions of 1985 dollars. The black line shows the budget as a percentage of GNP.



DIAGRAMS: OMNIGRAPHICS

The Soviets don't throw money away on flashy, popular programs.

they have been able to service and maintain their space stations for years at a time. Crews can be rotated, visited, and supplied. The Soviets have also collected a large volume of data on the long-term effects of weightlessness, isolation, and other factors inherent in the space experience. Much of this information is gradually leaking to the West, but it would be far more efficient if the U.S. could collect its own data on the long-term effects of living in space.

Last year the Soviets announced their intention to send an unmanned mission to Mars by 1988. The mission will include landings on the Mars moons, Phobos and Deimos—a first in the space race. One purpose of the mission will be to explore potential reserves of fuel, oxygen, and water for use in a future Mars colony. The Soviet announcement was surprising not so much for its content as for the fact that it was made at all. The Soviets learned early in the space race that challenging the United States in space always awakened the sleeping hare. After several "second bests," they have learned to keep quiet about their plans. They must be quite confident of their lead in the race to Mars.

The most surprising part of the Soviets' space program is that they have never succeeded in developing a superbooster that comes close to the Saturn 5 the United States used in the Apollo program. All their manned flights have relied on a rocket that was designed in 1954 as a first-generation ICBM. The Soviets have been able to afford a steady and fruitful manned program because they don't throw away funds on flashy, popular programs. In fact, the Soviets have never thrown away any of their hard-won technology as we did with the Saturn 1 and 5 developed for Apollo.

The Soviet program is not without its technical shortcomings, but its slow and steady progress is about to take the country to another planet. The recently launched successor to Salyut named MIR (Peace) will probably become the world's first permanently manned space station. The Soviet Union has test-flown four model shuttle craft in orbit. These are presumably the prototypes for what may become the Soviets' first reusable vehicle. One of these models may be primarily military; another looks remarkably like the American shuttle, right down to its piggyback configuration atop a Myasischev 4 transport plane. The Soviets have also conducted several suborbital tests of components of a giant new booster that could be ready to lift a space shuttle as early as 1987. The Soviets are making substantial, steady progress toward well-defined goals. It is up to us to deduce their unstated long-term goals from their near-term plans, but all the signposts point to a manned mission to Mars.

Prescriptions for NASA

What can the United States do to get back on track in space? To begin with, our government must decide on and adhere to some reasonable long-term goals in space. Within our lifetime, for instance, we should definitely plan for a permanent manned settlement on Mars. Such a settlement would reaffirm U.S. leadership in space. Even more important, as historians tell us, any civilization that ceases to explore begins to die.

A mission to Mars can be broken down into a series of steps that can be started now. First, a permanent U.S. space station should be built to conduct research on how to establish a self-sufficient colony in space and extract essential materials from near-earth bodies such as asteroids and dead comets. Such materials would include propellents (hydrogen and oxygen), life-support materials (water, carbon, and oxygen), shielding (any bulk solid material or debris), and building materials (dirt and metal). The station would also be used to develop the ability to manufacture basic products such as food, insulation, furnishings, cables, and other heavy objects that are prohibitively expensive to lift from Earth.

Second, an economic reassessment of the previously deferred solar power satellite (SPS) must be undertaken in light of the availability of these low-cost space resources. A successful SPS system could potentially supply the power needs of the entire world. Third, a fleet of spacecraft constructed largely with space-based materials should be used to launch an expedition to Phobos and Deimos. These two moons would serve as sources of propellent and life-support materals for all manned operations in the Mars system. Finally, on Mars itself, the previously developed technologies for self-sufficiency, solar-powered electricity, and the manufacture of heavy, low-tech products would be used in establishing the first colony. This entire undertaking could actually cost less than the Apollo program and contains the potential for continuing space activity at low cost.

Notice that this does not include going back to the Moon. The potential for a self-sustaining colony

there is much less likely because of the difficulty of finding water, oxygen, and metals.

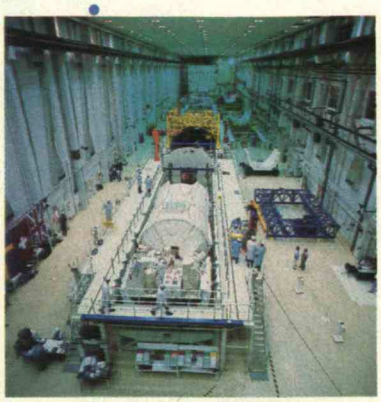
To meet those goals, NASA must be assured of long-term funding stability as enjoyed by DOD on some major weapons projects. NASA must also begin to adhere to its own charter. It should turn the operation of the shuttle over to an independent operating agency and go back to focusing on research and development. The president's Commission on Space debated the issue of divesting NASA of the shuttle but avoiding making such a recommendation. We call for it here.

Once the energies and monies of NASA are back in the R&D business, progress can be made in a few vital areas. Creating a new heavy-lift launch vehicle—either manned or unmanned—to lower payload costs should be the first priority. This vehicle could be an offshoot of shuttle technology—a second-generation shuttle. Or it could be an aerospace plane, capable of gulping its own oxygen out of the atmosphere until it is almost in orbit. (It would save launch weight by not having to carry its own oxygen.) Or it could be a "big dumb booster" of the sort flown since the early days of rocketry. Or it may be something unforeseen.

NASA should foster innovation by allowing separate R&D teams to develop plans for competing vehicles simultaneously. Only late in the development process should the agency decide which plan to follow. Though this may appear to be wasteful in the short run, it is far less profligate than developing an inferior spacecraft—like the shuttle—and being forced to use it because there is no alternative. We are convinced that this strategy can cut payload costs below $600 per pound, and possibly $200 per pound. Perhaps undreamed-of capabilities might emerge from such an effort.

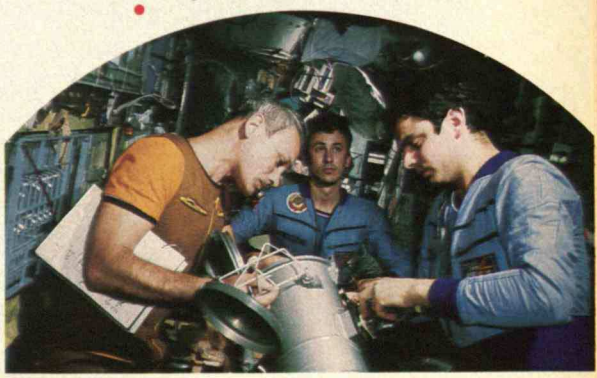
NASA should take greater advantage of launch capabilities that still work. NASA maintains that because the Apollo superboosters were scrapped, it would take 16 years to get back to the Moon if we made the decision to do so today. This means that we are twice as far from the Moon today as we were the day Kennedy first made his announcement. While it's too late to resurrect the Apollo boosters, NASA could use Titan ICBMs, launch vehicles that have recently been liberated from their silos because DOD no longer needs them, in space missions. After all, if the Soviets use the same launch vehicles for warheads and space missions, why can't we?

1981. The era of the space shuttle opened 20 years to the day after Yuri Gagarin's historic flight. *Columbia*'s successful maiden voyage made it the first reusable spacecraft in NASA's stable.



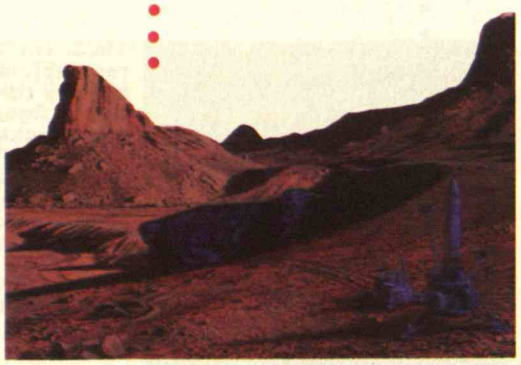
1983. The Spacelab research module was built by the European Space Agency and piggybacked aboard *Columbia*. The laboratory can house more than 50 experimental projects using instruments developed by the U.S., West Germany, Austria, Belgium, and France.

1984. Taking turns staffing Salyut space stations, Soviet cosmonauts have set many endurance records and logged 75 percent of all manned hours in space. Below, cosmonauts prepare to return to Earth after 237 days in orbit.

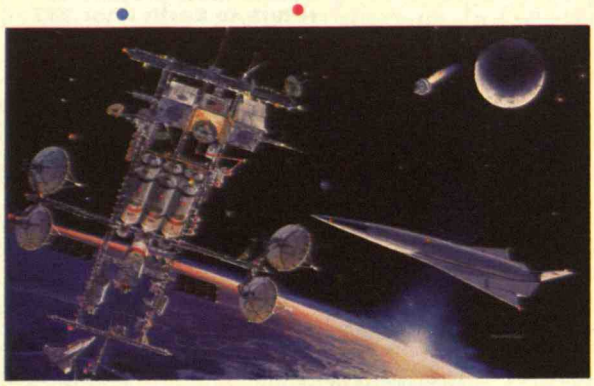


1986. The Soviet Space Flight Control Center monitors the first station-to-station flight in space. Cosmonauts traveled from the *MIR* space station to the *Salyut 7* space station aboard a Cosmos transport vehicle.

1986. China's Long March 3 rocket booster launched a second communications satellite this spring. China, Japan, and Western European countries such as France are vying for a piece of the action in space.



21st century. An artist's conception of a possible joint U.S.-Soviet Mars mission includes a planetary prospector provided by the United States to collect soil samples. The Soviet Union would provide the spacecraft for transporting the samples back to Earth.



21st century. An artist's conception of future space traffic shows an aerospace plane and a spaceport where a transport vehicle unloads its cargo. In the background, a two-stage transfer vehicle returns to a spaceport in Earth orbit from the Moon.

No single NASA program should be so large and all-consuming that it crowds out all other space-science efforts. A budget must remain to develop the planetary probes and other scientific packages to be used on the new heavy-launch vehicle when it is finally built. Exploratory probes to investigate the idea of using space-based resources such as oxygen, hydrogen, water, metals, refractories (for brick) and dirt would make excellent sense in the immediate future.

Finally, people should go into space only when they are essential. Manned missions should not be launched just because they are popular with the American people. But we must also be aware of the reflex to condemn all manned space activity as useless. We are far past that stage in our development.

In reworking a long-term space policy, the United States should consider cooperating with the Soviet Union. Both countries have individual areas of expertise: U.S. basic technology is superior and its computers are much more capable and reliable; Soviet experience with manned spaceflight and automated rendezvous is greater. The world's other space-faring nations also have a lot to offer—and a lot to gain from cooperating with the giants. A multinational expedition to Mars might well make the huge expense of such an endeavor affordable for humanity. Such an expedition might also foster global unity and a healthy sense of cohabitation on Earth, rather than the paranoid competition that now exists.

In time, we will be able to achieve even more exotic goals, such as planet-hopping to other solar systems. But for now the task is to reestablish a clear view of what lies ahead. NASA need not feel threatened by this short list of suggestions; its organization is essential to fufilling these goals. However, if the agency's entrenched bureaucracy continues to behave as it has for the past decade and a half, the American people might lose patience with space exploration. At this point, we believe the American public is still excited about space, and a simple change in direction could put NASA back on track and fulfill our most ambitious dreams. □

RUTH A. LEWIS is a free-lance science writer and science teacher. JOHN S. LEWIS is professor of planetary science at the University of Arizona's Lunar and Planetary Laboratory. He has served on NASA's Physical Sciences Committee, the Space Science Board, and numerous other governmental committees. This article is drawn from the Lewises' book Space Resources: Breaking the Bonds of Earth *(Columbia University Press, forthcoming).*

MIT

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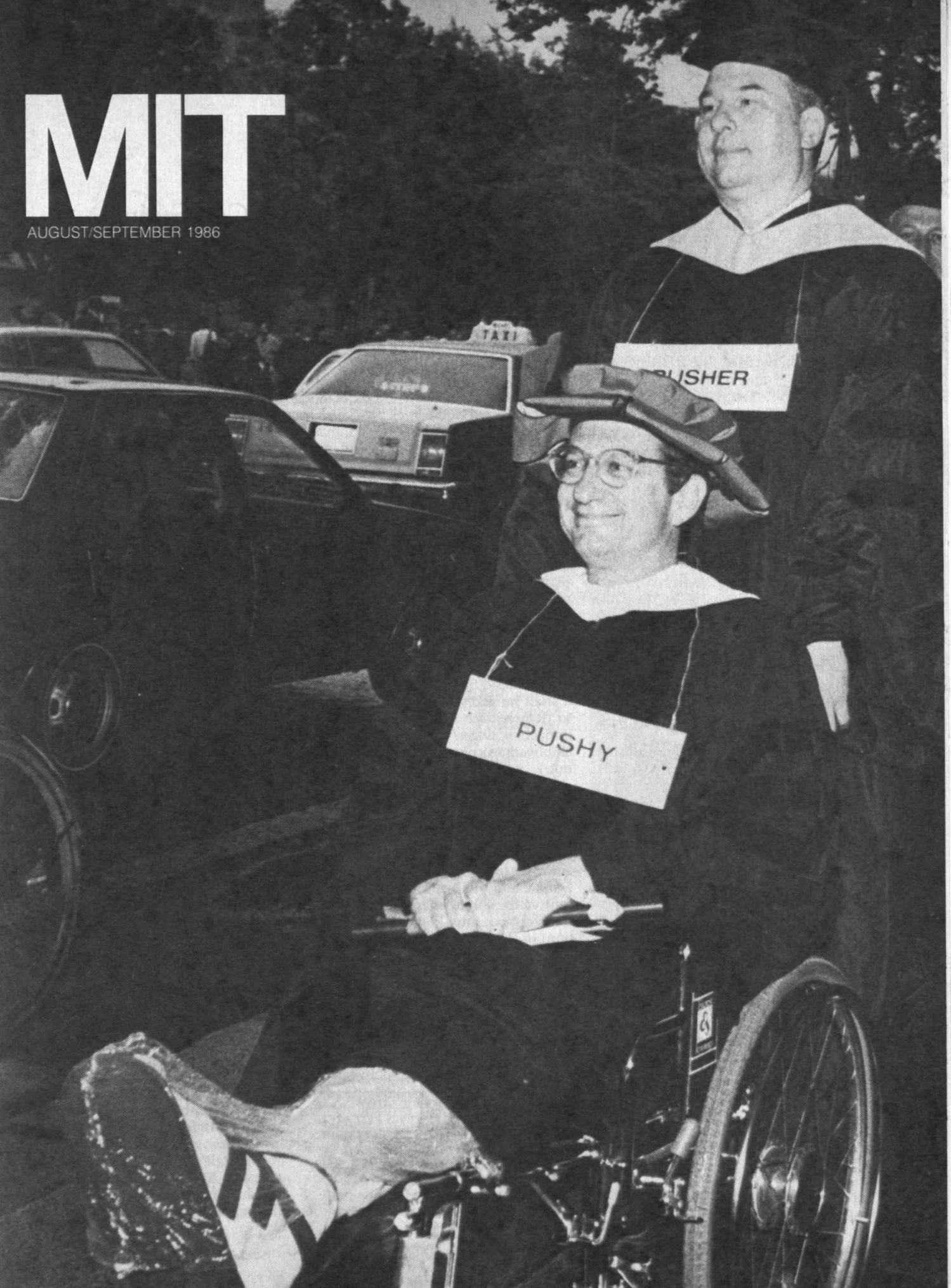

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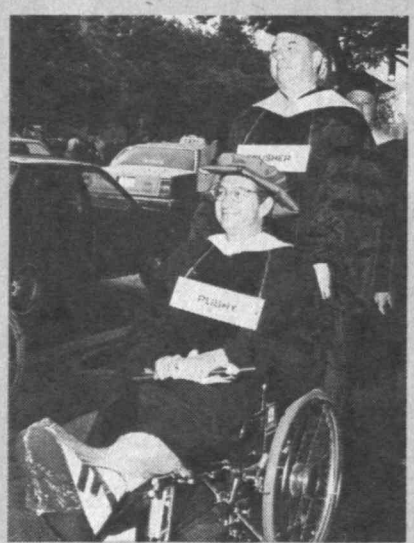


ABOUT THE COVER
The car that slid across icy roads and hit John Deutch last winter caused severe leg injuries that somewhat complicated his first Commencement as provost. Fellow member of the Class of '61 and Dean of Engineering Gerald Wilson provided the power for the wheelchair and the humorous signs, but he misspelled "pushee." Didn't he?

PHYSICS OF SPORT

BY MATTHEW DEADY, PH.D. '81

To Improve Your Golf Swing, Try Using a Book

Let me say this at the start: I am not a golfer. But it is a sport that absorbs many of my friends, not to mention my fellow physicists.

Almost 20 years ago, a group of physicists took an exhaustive look at golf. Their work led to the book *The Search for the Perfect Swing* by Alastair Cochran and John Stobbs, from which I will draw some of my numbers and much of my approach.

Let's start with the drive—the "power" part of golf. The golfer swings the club, the clubhead strikes the ball, and the ball sails down the fairway. The only actual interaction between the player and the ball comes in the millisecond or so when the head and the ball are touching.

(The impact is so short, in fact, that the clubhead might as well be swinging on a piece of string during the collision. Cochran and Stobbs used a driver with a shaft hinged just above the clubhead to demonstrate that at the moment of impact, it doesn't matter whether the clubhead is connected to the shaft or not.)

The interaction of the ball with the club is the same as that of any ball being struck: first it compresses, then it expands back to its normal shape, springing off the clubhead. In the process of compressing and expanding it loses some energy to heat, but about 40 percent of the initial energy of the club is transformed into kinetic energy (motion) of the ball.

In essence, the golfer's legs, hips, torso, shoulders, and arms have to work in a coordinated manner to deliver a lot of energy to the club. This is the famous "rhythm and timing" of golf.

One object of a good swing, then, is to have the head hit the ball at a high speed. The relationship between the speed of the club and that of the ball can be stated mathematically. Let's be simplistic for a start and assume that no energy is lost to heat. In that case, taking V as speed and M as mass (or weight) of the ball or the clubhead, we can use the conservation laws of momentum and energy to solve for the final ball speed in terms of the initial head speed:

$$V_{ball} = \frac{2\,M_{head}}{M_{head} + M_{ball}}\,v_{head}$$

That means that a seven-ounce clubhead travelling at 100 miles per hour before impact (fairly realistic numbers) will cause a 1.6-ounce ball to fly off at 163 mph. In a real collision, however, some energy is lost to heat, so the actual ball speed would be more like 135 mph.

Golfers may argue about the value of a heavier head, but by applying the formula, you can show that even a 40 percent increase in the weight of the head would only increase the ball speed by about 5 percent. You can get the same result by increasing your clubhead speed by 5 percent.

You can't make any last-second adjustments—by the time the impact is felt along the clubshaft, the ball is long gone. As in so many sports, it's still important to "follow through," but that is mainly to ensure a smooth and powerful motion before the clubhead hits the ball.

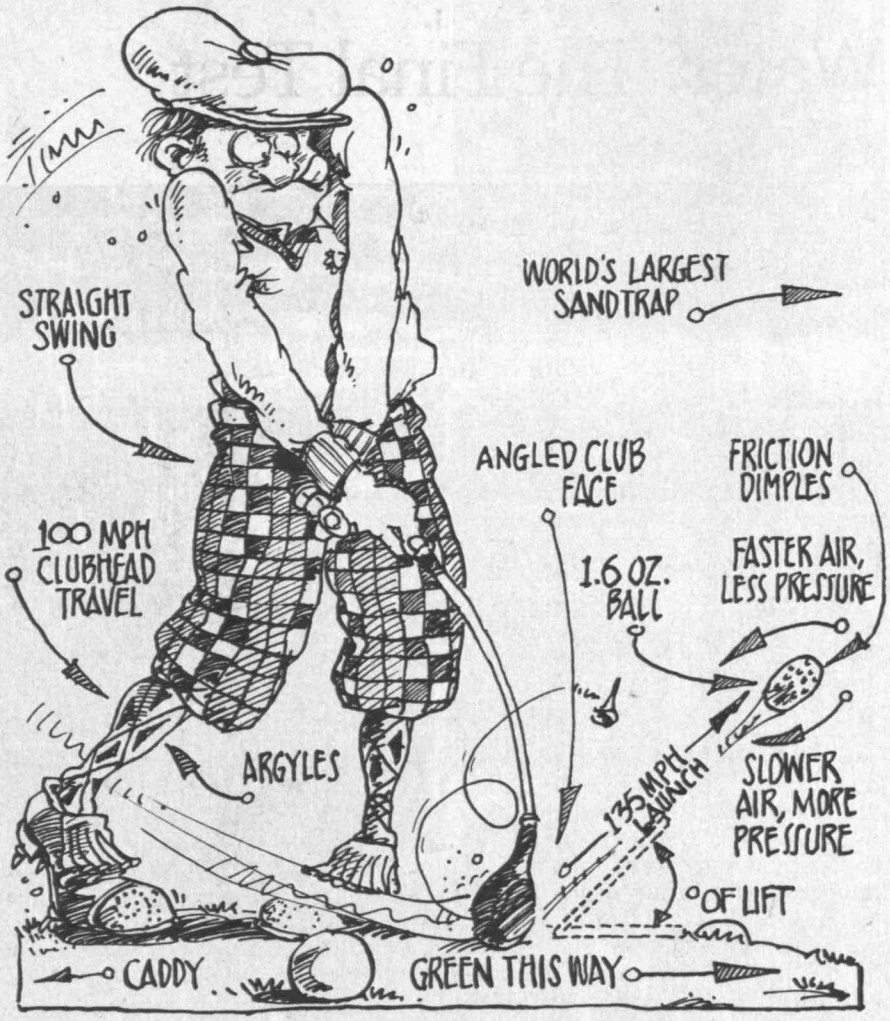
Power Isn't Everything

Even a non-golfer such as myself knows that the ability to control the direction and distance of the struck ball is as important as sheer power.

There are three reasons why golf balls don't go where you want them to: First, you hit the ball just fine, but are swinging in the wrong direction. Second, you don't hit the ball in the center of the clubface. Or third, the face is not square with the direction of the swing.

The first type of problem is straightforward. It's not to hard to see that a properly hit ball will go along the line you hit. If you aim wrong, don't expect the ball to read your mind.

MATTHEW DEADY, PH.D.'81, DOES RESEARCH AT M.I.T.'S BATES LINEAR ACCELERATOR CENTER AND TEACHES PHYSICS AT MOUNT HOLYOKE COLLEGE.



The other two problems are more subtle. If you don't hit in the center of the clubface, for example, the force the ball exerts on the club will actually twist the clubhead around its center. Striking off the toe makes the club face turn away from the golfer, while hitting on the heel has the opposite result, turning the face toward the golfer. In both cases, it is the twisting of the clubhead at impact that produces the misalignment, but the effect is to shift the diagnosis to problem three: a clubface that is no longer square with the direction of the swing.

It doesn't do any good to have a nice, straight swing toward the green if your clubface is pointing toward the sandtrap. The mistake not only causes general problems of misaiming, it also tends to put a sidespin on the ball. Sidespin causes hooking and slicing, the bane of golfers' existence and the source of most of their frustrations.

You can demonstrate what happens using a book and a ball of any kind. Move the book along a straight line to strike the ball with one of the flat faces. As long as the face remains square with the line of motion, the ball will travel in the direction the book was moving. But if the book face is not square with the movement, the ball moves along the face during the collision, rotating as it moves. The friction between the ball and the face imparts a spin to the ball. The golf ball is fairly light, so once it is airborn, the spin and its interaction with the air around the ball causes much more noticeable effects than you would get from a baseball or softball.

The primary interaction that makes a spinning ball change its path in the air is the same effect that keeps airplanes up: a difference in air pressure on one side versus the other. Look at the diagram of our golfer's perfect shot. The ball is moving from left to right; because all clubfaces are tilted upward to give lift to the ball, it rolled upwards on collision and left the clubface with backspin, in a counter-clockwise direction. Molecules in the air are slowed down on the bottom side and speeded up on the top side of the ball, due to friction with the ball's surface. This means the air is "thinner" on the top and exerts less pressure. The net effect is that the air below pushes up harder than the air above pushes down, and the ball is lifted.

(As the golf ball spins, dimples on its surface increase the friction between the ball and the air, maximizing the lift. A smooth ball wouldn't travel as high or as far.)

If, in addition to backspin, the golfer imparts spin around the vertical axis, the ball will veer to the left or the right. You will recognize this as the all-too-familiar "hook" or "slice."

Hooks and slices are not all bad. Properly understood and skillfully employed, they can help the player get around a dogleg or obstacle that makes a straight shot less effective.

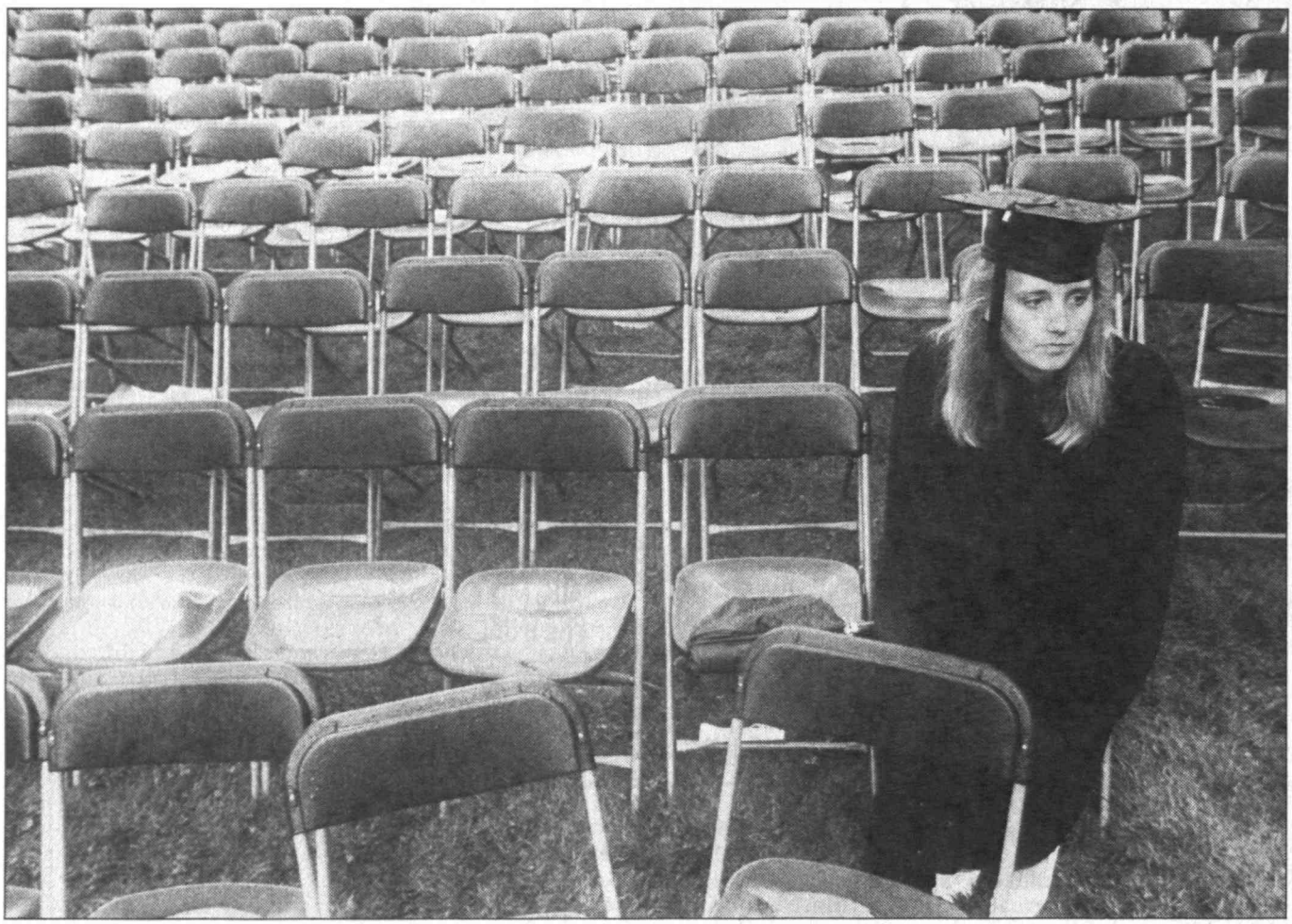
Without meaning to be dextrocentric, let's look at the right-handed golfer's shots. A slice—a shot that curves away from the golfer, to the right as a right-handed player looks down the fairway—results when the clubface also points in a direction farther away from the golfer than the direction of the swing. Try it with the book and ball; notice how the ball rolls to the outside of the book, picking up spin.

Hooks are just the opposite. The swing direction is outside of the direction the club is facing, causing the ball to slide to the inside and making it curve toward the golfer—to the left as a right-handed player looks down the fairway.

Accurate observation of these clues and proper remedies are where the club professional, not the physicist, comes in handy. So don't call me when you land in the rough on the 14th. I'm likely to only be able to explain what *should* have happened. □

ILLUSTRATION: JON McINTOSH; COVER PHOTO: PAULA LERNER

Trial by Water: The Final Test



For the Class of 1986, the level of difficulty and discomfort in receiving the M.I.T. degree was congruent with the difficulty of earning it.

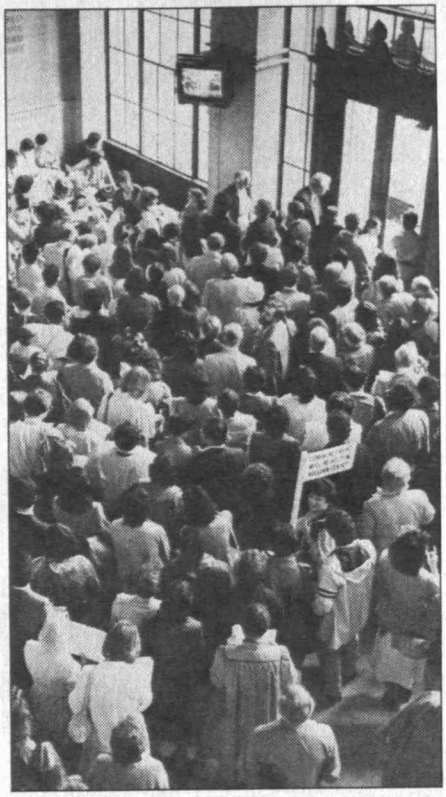
On the morning of June 2, when 1,800 seniors and graduate students filed into Killian Court to receive some 2,000 degrees, the heavens opened over their heads. Rain dominated the occasion, turning each chair seat into a puddle, leaching dye from gowns and mortarboards to streak faces and clothes, and all but shutting out the really definitive players in any American graduation—the amateur photographers.

It was not just wet, it was cold. Men and women shivered as they lined up to receive degrees, to say nothing of their parents and guests. Even the 7,000 plastic raincoats passed out to visitors could not make them comfortable.

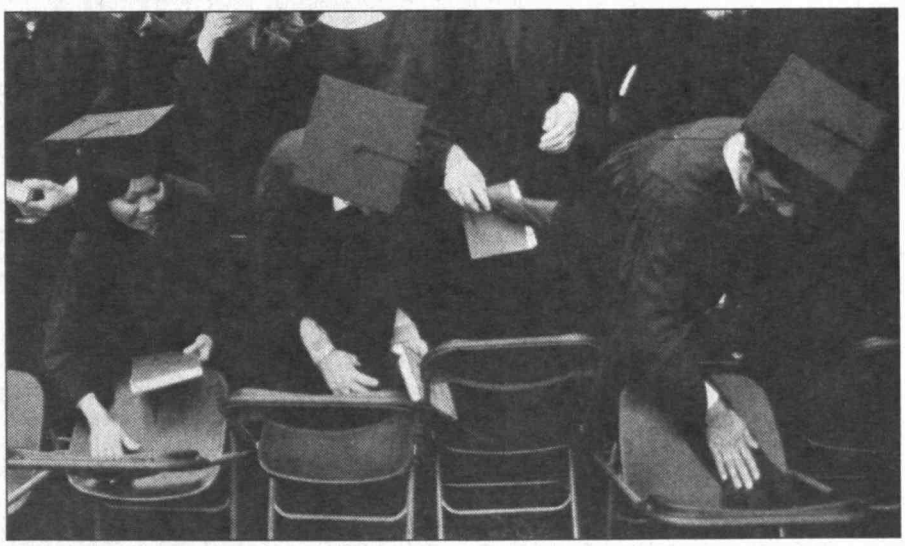
The planning for a picture-perfect Commencement '86 had been going on in one way or another since the final moments of Commencement '85, and had accelerated in the month before the event:

Chairs for graduates and 6,000 visitors were set up in Killian Court, the sound system was installed, the stage constructed, the tents and tables for receptions assembled on the lawn, and the plantings in front of the stage were a ready backdrop for a thousand photographs. Even the rhododendron, on cue, had come into their traditionally lush Commencement flowering.

The back-up site was ready. In case of intolerable weather, the plan was to move the ceremony to the Athletic Center, the largest indoor area at M.I.T. But while the speeches were going on, there would be seating for only the graduates, faculty, and a few special guests. Family and friends would have to listen from Kresge Auditorium and the Sala de Puerto Rico. Speeches complete, the graduates would reassemble by schools in various corners of the Athletic Center—engineering downstairs, other schools upstairs—where the deans



The ceremony began with everyone tipping puddles off of their chairs and holding umbrellas (and one plastic porpoise) and ended with guests packed around TV monitors indoors and graduates retreating to dry ground as soon as they received their degrees.



would hand out degrees. In that case, only a portion of the guests could be seated for the second half of the ceremony.

At 6:30 Monday morning, there was the first of many conferences of key players. Mary Morrissey, executive officer for Commencement, Professor Donald Harleman, Sc.D.'50, chair of the Commencement Committee, and John Berlinguet, the Physical Plant Department delegate to the committee, considered the weather report. "Showers around 10 a.m; then the storm will move out to sea." Surely it would be better to endure a short shower than deprive many guests of an opportunity to share the occasion with their own special graduate. The group recommended to President Paul E. Gray, '54, and chairman David S. Saxon, '41, that they stay with the outdoor site. The degrees were then unloaded in Killian Court in two stacks—one for undergraduate degrees, another for all higher degrees.

At 9:30, the Forecast Was Optimistic

A 9:30 a.m. check of the weather radar on the Green Building showed the storm moving swiftly to the Northeast, visibility improving. At 10 a.m. Alumni President Milton Bevington, '49, was leading the procession into Killian Court. Next came the red-jacketed Class of '36 led by Alice Kimball, and followed by students and faculty. By then the predicted showers were dampening their "day in the sun," but graduates gamely tipped puddles off their chairs, sat down under all the umbrellas they could assemble; and the ceremony began.

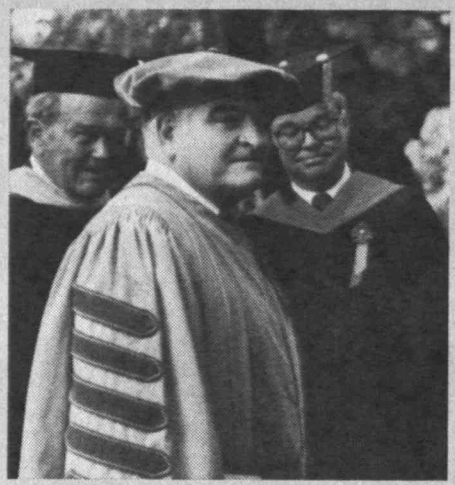
It was not long before the throng of visitors filled all halls opening to Killian Court, and the Infinite Corridor was thick with the smell of perfume and wet fabric. The Department of Mechanical Engineering had had the foresight to set up chairs in its lounge facing the court, and it was packed. The undergraduate physics office in Building 4 looked like the pressbox at a football game—everyone watching out a wide bank of windows. Families clustered at every landing on the stairwells affording a view, however limited, and more settled to watch television monitors in the very lecture halls where the degrees had been earned.

Those watching the monitors heard a muffled roar as Class President Vivienne Lee announced the light sculpture for Lobdell and the scholarship fund that made up the class gift. A hurried trip to the doors at Lobby 10 showed the reason: the rain had intensified to a downpour, and the microphones had picked up the sounds of more than 2,000 people reacting to cold, pelting rain. But the Class of '86 held its ground.

President Gray reported a parent's quip: "After the soaking I've taken from this place in the last four years, what's a little rain?" Then he went on to make an announcement that was popular even in such uncomfortable conditions: the Center for Space Research will be named for Ronald E. McNair, Ph.D.'76, a mission specialist on the space shuttle *Challenger* who died when the shuttle exploded in January of this year. McNair, said Gray, is a model of "achievement tempered by an uncommon wisdom and an abiding love of mankind," and a man who took the long view—a constellation of qualities that will be required of graduates in this age of telescoping time and space and es-

COMMENCEMENT PHOTOS: FRANK REVI, '86; PAULA LERNER

Taking the Long View in a Shrinking World



(Following is an abridged text of the Charge to the Graduates by President Paul E. Gray)

While your horizons may seem limitless at the moment, the world you enter is in many ways much smaller than the world of your ancestors. In recent decades, time and space have become compressed—the result of scientific advances and technological innovation. I think particularly of the influence of electronics and physics on international security and communication. Today we are able to speak, hear, see, and reach across vast distances. We push time around in our travels. And the consequences of each act reach further and faster than ever before.

Contrast this with the state of the world at the time of this country's founding. In the spring of 1775, there was a battle involving fewer than 200 men on Lexington Common in Massachusetts. Shortly after that, there was another battle in nearby Concord. Out of those battles began a war for independence that changed forever the nature of this continent. But it was more than two months before the House of Commons in London learned that anything had happened.

Shrinking Time and Space

Now consider our circumstances today. In the spring of 1986, something occurs in Chernobyl, in Soweto, or in Libya, and if we don't see it happening live on television we surely see it replayed and analyzed on that evening's news. This instantaneous quality of communication—about events, about ideas—is a product of technologically-driven change. At the same time, it is an engine of change—as people and governments act and react on a time scale that would have been impossible 200, even 50 years ago.

I was struck by a recent essay in *The New Yorker*. The author, commenting on the waves of fear generated by political clashes halfway around the globe, said:

"We know that a universal geography, discovered by modern physics, cancels out the human, earthly geography that has always given us our feeling of safety. In the scale of the new geography, in which distance is measured in light-years and explosive power in millions of tons of TNT, blue oceans lose their immensity, and the earth itself shrinks to the size of a pea. In the scale of that geography, which is the essential geography of our time, the boat that burns in the water . . . is no farther away from us than the television screen in our living room which shows us the scene."

This compression of time and space will require of you—more than of any previous generation—an ability to take the long view in your personal and professional decisions: a perspective which embraces contrasting values and cultures, which unites an understanding of the contemporary scene with a sense of history, and which keeps faith with human potential. When space and time were virtually unlimited, there was, on the one hand, more time for thoughtful consideration of alternative courses of action and, on the other, less urgency for people to evaluate their acts in terms of distant countries or later generations. Now this perspective—this long view—must be constantly before us, must be a part of us, for we know that what we do today will affect not only our contemporaries near and far, but tomorrow's children as well.

Why Is As Important As How

The right decisions will not always be obvious, will not always be easy. But the choices you make in your life will be sounder if you can bring to them the sense that knowing *why* is as important as knowing *how*.

Perhaps the best way for me to explain my hopes for you is to recall one of our graduates who was a shining example of the extraordinary quality we have come to expect of those who have been part of M.I.T. I speak of Ronald E. McNair—one of the *Challenger* astronauts, who received his doctorate in physics from M.I.T. just nine years ago. Ron's life was one of stellar achievement, bright promise, and clear vision. Speaking of his view of the earth from space—and he, if anyone, had a long view—he said:

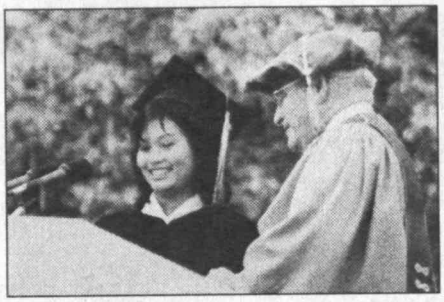
"Truly there is no more beautiful sight than to see the earth from space beyond. This planet is an exquisite oasis. Warmth emanates from the earth when you look at her from space . . . My wish is that we would allow this planet to be the beautiful oasis that she is, and allow ourselves to live more in the peace that she generates."

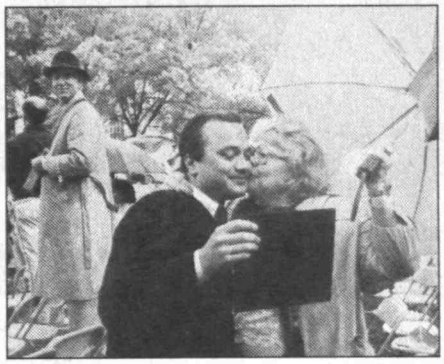
Ron gave much of himself to M.I.T. and to the people of M.I.T., and he was a symbol to a whole generation of young people around the nation of the best qualities that I can hope for you. It was these qualities in Ron that drew the Institute family together to remember and to honor him. I am pleased today to report that the governing board of the Institute voted to name the building that houses M.I.T.'s Center for Space Research after Ronald E. McNair.

The faculty, students, and staff in this center are dedicated to exploring space and understanding the cosmos. Nothing could be more fitting than to have Ron's name—and his spirit—associated with that mission and this campus.

As you undertake this next stage in your lives, I wish for you a life that is rich in opportunities to stretch your talents, your interests, your imagination, and your vision of this small planet as a beautiful oasis . . . generating peace.

And as you depart from this special place, I wish you good luck and Godspeed. □





calating internecine and international conflict.

Commencement speaker William R. Hewlett, S.M.'36, reminded graduates of the slipping international economic position of the United States. But Hewlett believes that the engineering creativity of which the U.S. is capable, particulary if applied to manufacturing as well as research and development, is equal to the task of restoring the nation to its former position of economic leadership.

What's more, said Hewlett, the substantial changes in American industry that a turn-around in manufacturing will require will make the coming years a time of opportunity for new graduates. As large corporations are stirred and refocused, talented newcomers can rise more quickly to positions of responsibility, he said.

As the speakers finished, the ceremony reached another decision point: should they carry on in the rain or move indoors? Knowing that there would be a two-hour delay while the degrees were moved to the Athletic Center and rearranged for distribution by school—prolonging the misery for people already wet—the President decided to carry on.

Unique Display of Parallel Processing

At which point, a major innovation, one which President Gray termed "an unprecedented display of parallel processing," slipped into gear so flawlessly that it had the look of long tradition. Each name was read, each degree handed to its owner, but the time required to do it was halved, as Provost John M. Deutch, '61, presented graduate degrees while the President, as always, presented undergraduate degrees. As *Tech Talk* later pointed out, "M.I.T. couldn't have picked a better year" to shave an hour off Commencement.

As graduates received their degrees, they waved mortarboards and jumped in the air with only a little less than their usual joie de vivre, then headed straight past their chairs for shelter. At 12:35 the rain belatedly stopped, and Bevington led the faculty, in its medieval ceremonial attire, out past empty rows of chairs and ground strewn with sodden Commencement programs.

Moved indoors, the receptions started off slowly. The tables of cookies and sandwiches spaced around the edges of the bare Athletic Center had none of the charm of the lawns of du Pont and Lowell Courts at other, sunnier, Commencements. But soon clusters of graduates filtered in, introduced their friends to their families (about whom each had surely heard much over the years); the élan of celebration was recaptured.

Back at the Coop, the sweatshirt department looked like a fire sale. M.I.T. insignia in every shape and size transformed rather ordinary clothing, household goods, and office supplies into momentos of a relationship not always enjoyed but never taken lightly—a tie to M.I.T. The counters were beseiged by shoppers for whom this was perhaps a first and only trip to Cambridge.

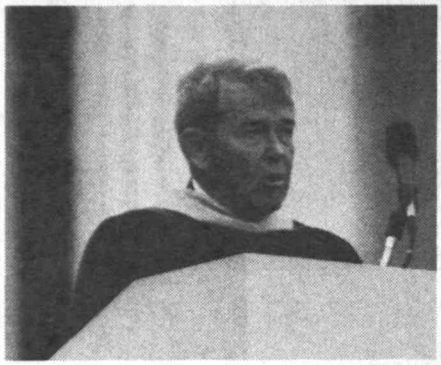
Though it was all over by mid-afternoon, the reverberations continued for weeks. Letters and phone calls to Gray, Harleman, and Morrissey voiced the distress that had been apparent to all. In their responses, all three agreed that the distress was well-founded and that the Institute was trying to extract every possible lesson from the experience.

"I don't think anyone felt worse than the people who actually worked to prepare for Commencement," said Morrissey. "I know I'll never get over it."

The Institute took what measures it could. President Gray ordered a reprinting of the Commencement programs so that every graduate could be sent a dry copy. A special edition of *Tech Talk* and a letter expressing the Institute's regret that graduation had been such an ordeal were also mailed to the home addresses of graduates. Hoods (presented to those who earned higher degrees) and diplomas that were damaged by rain are being replaced if they are returned to the Registrar's office.

Perhaps the most promising innovation the Institute is considering is a canopy over a substantial portion of Killian Court, something that would protect graduates and guests from sun and rain alike. Berlinguet is looking into the possibilities for covering such a large area, and he will report to the Commencement Committee. Cost is certainly a factor, says Berlinguet, since this covering will be used for only four hours per year, albeit a very important four hours in the life of every alumnus and alumna.

If I had one, I think I'd frame and display my rain-soaked 1986 M.I.T. diploma. It is the undisputable mark of one who can survive any test of endurance.—*Susan Lewis* □



Creativity Needed to Reinstate U.S. Leadership

(Following are excerpts from the Commencement address by William R. Hewlett, S.M.'36, vice-chairman of the board of Hewlett-Packard Company.

In the 50 years since I walked across this stage and was given a piece of paper that said I was a Master of Science, I have been intimately associated with the creative process that is so important to our modern, high-technology culture. I felt it might be appropriate, therefore, to share with you some random thoughts on creativity and its importance in today's society.

When I was preparing this address, I asked Chuck House, who heads the Hewlett Packard engineering productivity program, what he thought about creativity. With a twinkle in his eye, Chuck said, "Creativity is what screws up my engineering program."

Thomas Edison is alleged to have remarked about his laboratory, "There ain't no rules around here. We're trying to accomplish something."

I cite these two comments because they say a great deal about the creative process. It works best when not too structured, but it must, in the long run, be tamed, harnessed and hitched to the wagon of man's needs.

But first let me set a background for this country's renewed interest in innovation and creativity. By 1983, it was increasingly evident that we were losing the competitive edge that for so long had characterized the American economy. To better understand this problem, President Reagan created a high-level commission of distinguished business leaders and educators to ". . . review means of increasing the long-term competitiveness of United States industry at home and abroad, with particular emphasis on high technology . . ."

The commission concluded that "our ability to compete in world markets is eroding. Growth in U.S. productivity lags far behind that of our foreign competitors. Real hourly compensation of our work force is no longer improving. U.S. leadership in world trade is declining. Finally, pre-tax rates of return on assets invested in manufacturing discourage investment in this vital core of our economy."

One of the commission's primary recommendations was to "create, apply and protect technology. Innovation spurs new industries and revives mature ones. Technological advances lead to improved productivity, an essential ingredient for our standard of living."

In essence, this recommendation was two-fold—to create technology and improve productivity.

Same Data, Different Insights

How do I define creativity? Nobel Prize winner Albert Szent-Gyorgyi provided a good working definition when he said, "Discovery consists of looking at the same thing as everyone else and thinking something different."

The trouble is that creativity is really a poly-faceted discipline. It is very difficult to spot a creative individual just by looking at a resume. Establishing an environment that fosters creativity and observing who flourishes is probably the best way of finding this elusive characteristic.

I'd like to distinguish between two kinds of creativity. One is spontaneous, in which an individual sees a complete and elegant solution to an interesting problem. The other I call "creativity on demand," in which specific objectives are established and must be met, but with a great deal of flexibility in how the results are to be achieved.

Intellectual curiosity is a great source of creativity. An example of this is demonstrated by Nobel Prize winner Luis Alvarez, a long-time member of the Hewlett-Packard Board of Directors. While visiting Egypt, Luis became interested in the fact that no major burial chamber had been found in the Pyramid of Khephren and began to muse about how one might determine if such a chamber did exist. Luis was familiar with cosmic rays and knew they might be suitable for x-raying the pyramid.

Careful investigation led him to conclude that if he had been asked to design a proper radiation source for this purpose, it would have been the mu meson, an important component of cosmic rays emitted by the sun. It exactly fitted the need.

With these thoughts in mind, he went to the chancellor of University of California at Berkeley who, on the basis of Luis's analyses, provided a small amount of money to carry out the experiment. This study was not a normal function of a physics department, nor was financing it that easy. It was just a fascinating subject that the chancellor thought might add to man's knowledge of the past.

Luis also received the enthusiastic support of the Egyptian government and the experiment, in due course, successfully proved that there was no such chamber.

Creativity on Demand

Let me now turn to the development phase of creativity, the "create on demand" about which much has been written, primarily because there are techniques to enhance it.

Projects do not always progress at a steady, uniform rate. Sometimes progress is stymied by a very difficult problem. The problem might be overcome by a clear, technical breakthrough, but more often than not, it is bypassed with a compromise solution I like to call a "hot patch." If there are too many of these "hot patches," you'll probably wind up with a very cumbersome solution to the problem.

My company often employs retired engineers or scientists on a part-time consulting basis. One such was Harald Friis of Bell Labs. He could get Hewlett-Packard engineers to step back and view their work as a whole. He would ask, "What are you really trying to do? Are you on the right track, but feel you have too many hot patches?" Or, "Are you really on the wrong track and need to make a fresh start?" In this exchange of ideas, I have often seen younger re-

searchers learn new ways to harness and use their creative instincts.

Needed: Creativity in Manufacturing

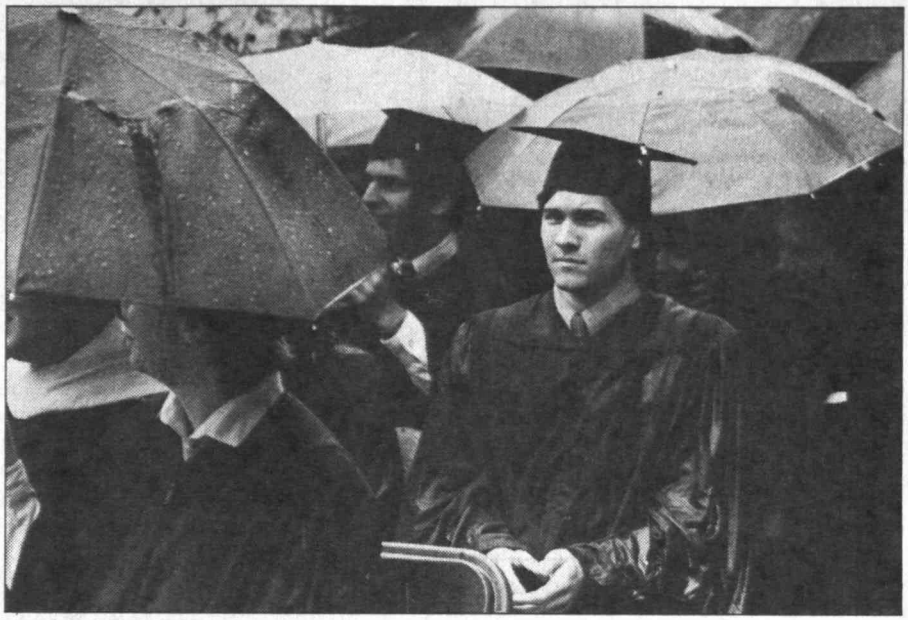
Now, let's look at how creativity can help increase productivity and improve quality. This challenge is clearly defined by the findings of the President's commission. Modern technology must be used to improve productivity. We need the same creative effort in the production process that we now lavish on the development phase.

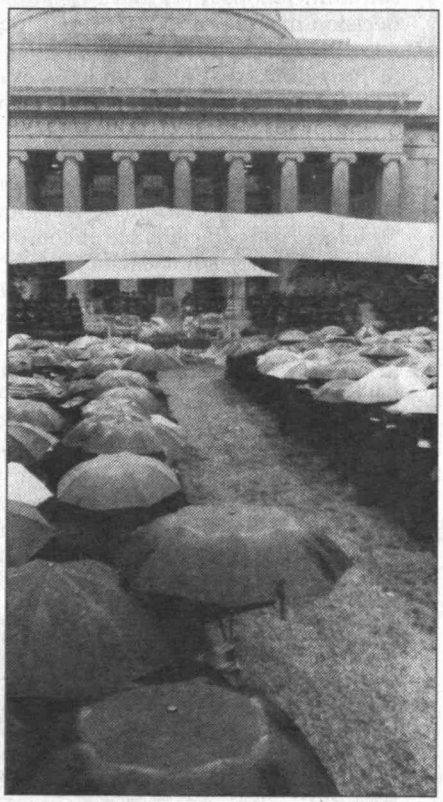
There is already a great deal of technology readily available that can be used to improve quality and manufacturability of a product. In many cases, however, U.S. industries are not taking advantage of this knowledge, although much of it originated in the U.S. We need new ideas and new leadership in this quest. Here, the universities have a very real responsibility to provide a theoretical base for quality and efficiency in the manufacturing process. I was delighted to learn that this trend is already under way at this institution. But, after all, what else would you expect?

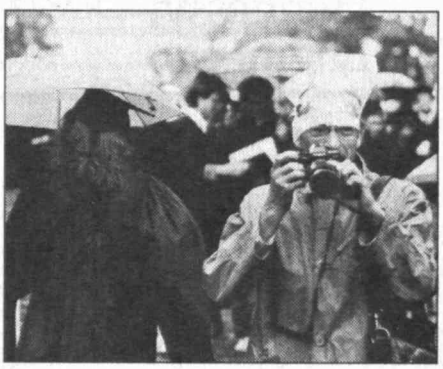
Creativity will play a vital and critical role in our increasingly high tech society. Hewlett-Packard's president, John Young, puts it this way: "Creativity is the only American competitive advantage left." Industry is going to have to make some drastic changes in how it views the importance of the research and development program and the necessity of increasing productivity. There is comfort and safety in tradition, but change must come, no matter how painful or expensive it may be.

From your standpoint, this situation is anything but bleak. This is the time when the best and the most creative minds will be sought out and placed in positions of key responsibility.

It may well turn out that the present period will be looked back on as one of unprecedented opportunity for the scientifically-minded. I hope so. I wish you success, happiness and great bursts of creativity in all of your endeavors. □







Vice-President for Computing

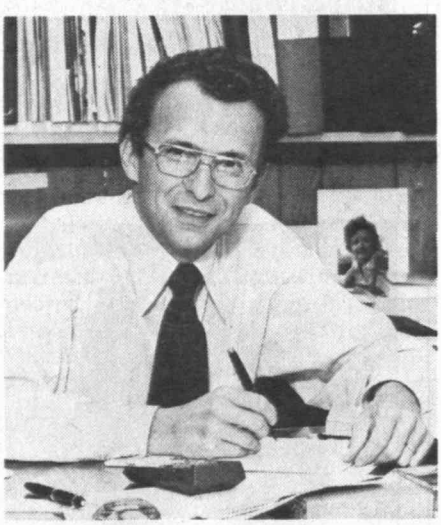
James D. Bruce, Sc.D,'64, formerly director of information systems, now has the rank of vice-president and, with it, two major responsibilites:

□ Directing the development, integration, and effective use of computing and communciations resources for planning, decision-making, and day-to-day operations throughout M.I.T.

□ Providing computing and communications resources to faculty, students, and staff for teaching and research.

Senior Vice-President William R. Dickson, '56, to whom Bruce reports, says the new appointment recognizes "the increasing importance of computer and communcation systems in all aspects of M.I.T.'s work." Bruce himself sets the goal of developing "a coherent strategy"—a three- to five-year plan for using new technologies for administrative computing needs. Such a plan already exists for educational computing in the form of Project Athena, says Bruce.

Before his new appointment was announced, Bruce had completed a strategic plan for administrative computing at M.I.T. Now, he insists, "the most important element to success in implementing that plan will be to get teams of people from different parts of the Institute working together—absolutely essential." A cornerstone of this program is the appointment of four assistants, one to work with each of the Institute's other four vice-presidents.



J.D. Bruce

Bruce came to M.I.T. as a graduate student in 1959 and joined the faculty upon completion of his doctorate. Since then he's been executive officer of the Department of Electrical Engineering and Computer Science (1969-71), associate dean of the School of Engineering (1971-79), and director of the Industrial Liason Program (1979-83). He holds the Gordon Y Billard Award (1978) for "untiring contributions to M.I.T. in administration, engineering education, and devotion to students." □

Pathway Offers Minority Opportunities

To recruit a greater number of academically talented Black Americans, Mexican Americans, Puerto Ricans and Native Americans, M.I.T. has established the Pathway to the Future Program.

The four-part program provides incentives that are expected to attract underrepresented minorities, according to Michael C. Behnke, director of the Office of Admissions. Information on the new plan will be sent to high schools throughout the United States and Puerto Rico.

Information has already been mailed to the 193 minority students offered admission to the class of 1990, with the intent of encouraging them to accept that offer. This is the largest number of minority students ever accepted for a freshmen class at M.I.T. If enrollments occur in the same proportion as in past classes, there will be about 105 underrepresented minority students in the 975-member Class of 1990. Behnke noted that students offered admission

represent the top minority students in the country, and they are courted by many of the top schools.

Minority members of the class of 1990 will be offered three exisiting minority support services—Second Summer Program, Project Interphase, and Special Financial Aid Consideration—and one new plan, the Practical Experience Program, which together comprise Pathway.

Called the "centerpiece" of Pathway, the Practical Experience Program will seek out summer employment for undergraduates. In addition, students will be counseled on how to qualify for positions in a variety of fields such as business, planning, engineering, and banking. This program will operate out of the Office of Career Services and Preprofessional Advising.

The Second Summer Program focuses on opportunities in engineering. Students spend three summer months at the end of their first year working in the design or research department of a major engineering corporation.

Companies which employ Second Summer participants pay for travel expenses from Cambridge to the place of employment and back, as well as a salary. M.I.T. will send a member of the faculty to meet with Second Summer students and their supervisors at the work site, to ensure that the work assignments are challenging.

Project Interphase is a residential summer orientation program that offers incoming minority freshmen an opportunity to establish contacts at M.I.T., learn about the Institute's resources, and gain exposure to core subjects before the fall term begins. Students earn elective course credits, discover undergraduate research opportunties, and meet faculty and student services staff.

Special financial aid consideration is given to students from low-income families. Because many minority families must pay more for basic necessities, the national college need analysis guidelines may not adequately reflect underrepresented minority families' experience, Behnke said. Recognizing this, he said, M.I.T. reduces the usual parental contribution for lower-income minority families.

This reduction in the parents' contribution is applied each year and those minority students who must stay at M.I.T. longer to gain a degree will also find that financial aid is available for a ninth or tenth term of study. □

Corporation Elects Eight

Eight new members were elected to the M.I.T. Corporation at the Corporation's quarterly meeting just before Commencement.

Elected to five-year terms were:

□ Sarah A.L. Tabler, '85, (nominated by graduates of recent M.I.T. classes) now employed at Scientific-Atlanta in Georgia.

□ E. Milton Bevington '49, president and chairman, Servidyne, Inc., Atlanta.

□ Ernest U. Buckman '46, chairman, Oliver Realty, Inc., Pittsburgh.

□ Alex W. Dreyfoos Jr. '54, president, Photo Electronics Corp., West Palm Beach.

□ Joe F. Moore '52, president, Bonner & Moore Associates, Inc., Houston.

□ DuWayne J. Peterson Jr. '55, executive vice president, Merrill Lynch & Co., Inc., New York City.

□ Charles H. Spaulding '51, president, Spaulding Investment Co., Cambridge.

□ Morris Tanenbaum, executive vice president, AT&T, New York City.

Bevington, Buckman, Dreyfoos, Moore and Peterson have served or are serving on the Corporation Development Committee. Moore served as a member of the Corporation from 1978 to 84. Tanenbaum has been a member of the Visiting Committee for chemical engineering (1964-67) and metallurgy and materials science (1968-76). Tabler was a member of the Corporation Joint Advisory Committee on Institute-Wide Affairs (1982-84) and was a student member on the Corporation Visiting Committee for the libraries and for the Artificial Intelligence Laboratory. □

The Smell of the Oil, the Squeal of the Tires

Let's face it: most folks who harbor a passionate interest in race cars will never be closer to one than the pages of *Road & Track* or the stands at Indianapolis. Unless, of course, they are M.I.T. students, a species accustomed to defining almost any endeavor as a do-it-yourself project.

In 1983, Mark Sztenderowicz, '82, and Eric Balles, '80, then graduate students at the Sloan Automotive Laboratory, decided that affordable automobile competition was a reachable goal. So they formed the Tech Sports Car Club.

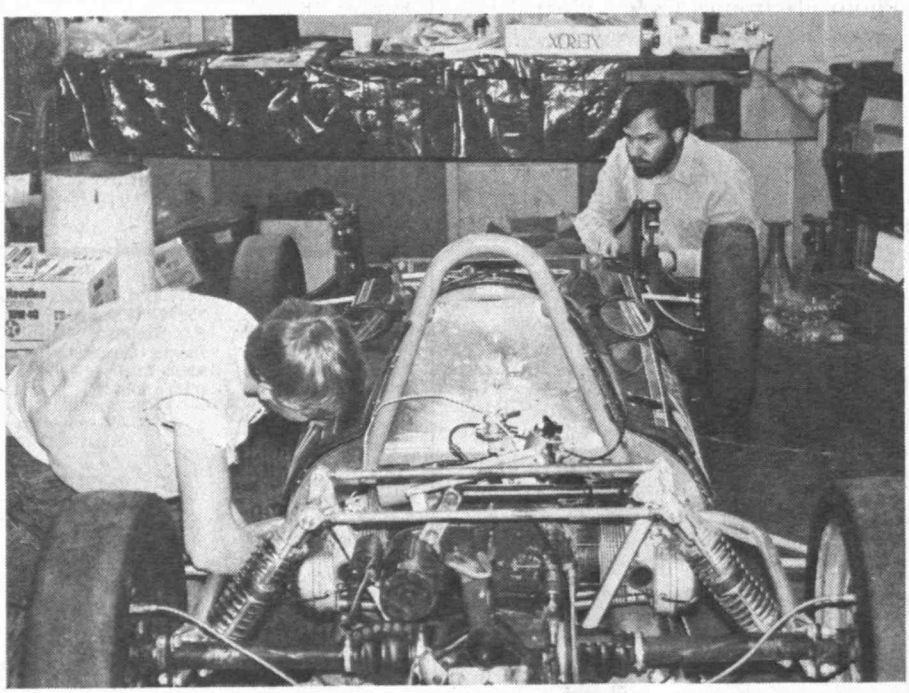
After two years of serious fund-raising, the club was able to buy a Caldwell D-13s Formula Vee racing car, making it apparently the only campus-based group in New England fielding a car.

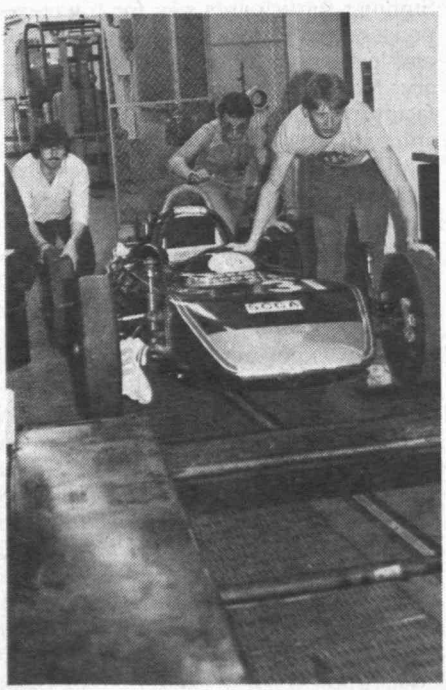
The car was a bargain at $6,000, and already steeped in M.I.T. connections. It had been built by RaceWare, a company launched and headed by Norman Marx, '71. He had taken over the dies and plans from the company that created the car, Autodynamics of Marblehead, which in turn had been helped with aerodynamic testing of its first car by Professor Emeritus Elmer Larrabee, S.M.'48, using an M.I.T. wind tunnel.

Marx, a life sciences major, had been initiated as an undergraduate into the excitment of the racing world by a previous incarnation of the Sports Car Club. He remembers his first visit to Autodynamics on a class trip with a fraternity brother who was taking Larrabee's aerodynamics course. It proved to be a pivotal experience for Marx, who went to work for Autodynamics after graduation and never looked back.

Marx serves as a resource for the present Sports Car Club, whose members have spent hundreds of hours rebuilding every system of their car. In their first racing season, 1985, they even recorded a first-place finish in one of the Corvettes of Massachusetts races. They expect to enter some 30 events across the Northeast during the current April-October 1986 season, with about half a dozen drivers.

The club's 25 members include graduate and undergraduate students and three staff members from Draper Lab, and all are potential drivers. Earning a



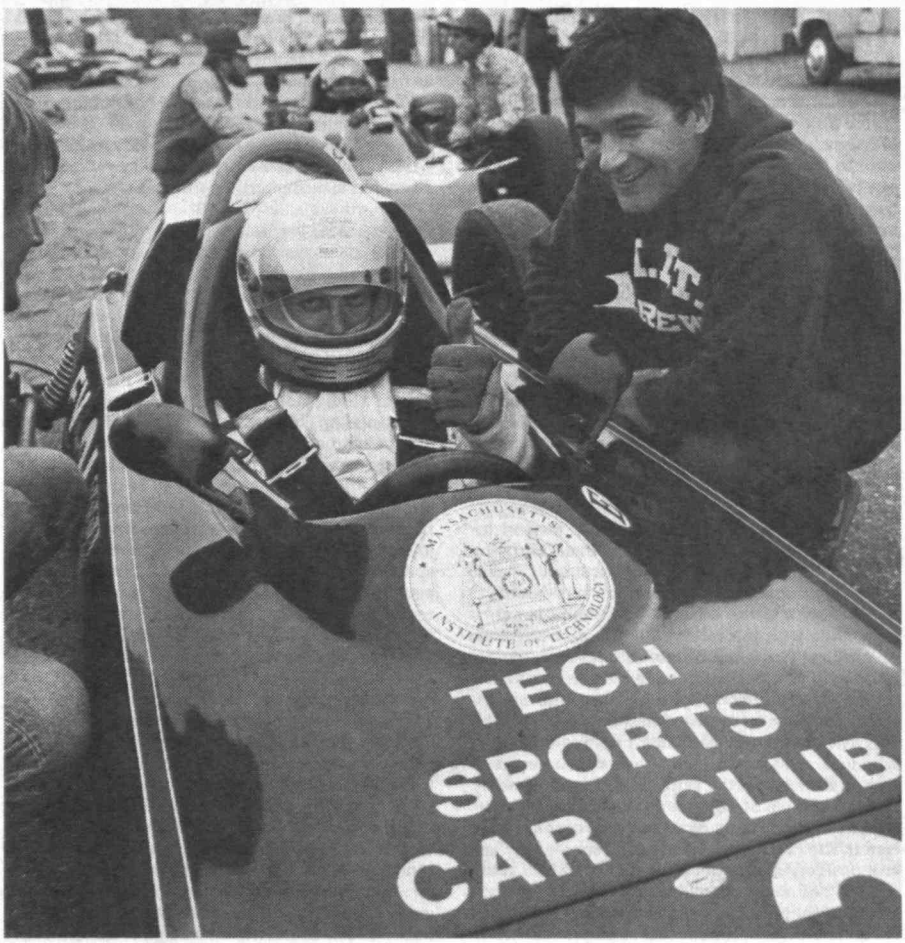


Tech Sports Car Club members learn the reality behind the excitement: it takes 50 hours of maintenance for every hour of racing.

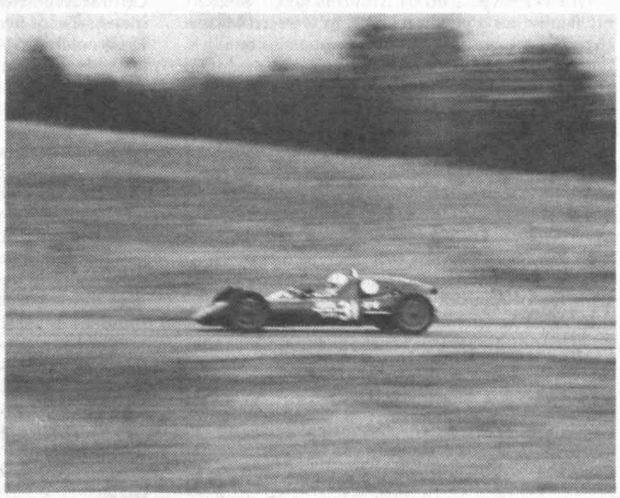
competition license and logging hours on car maintenance are the primary requirements for drivers. An estimated 50 hours of maintenance are required for every hour of racing; clearly, this is no activity for the glory-hound.

Almost as incessant as maintenance is the need for fund-raising. The money to buy the car came from grants and loans from the School of Engineering, the Sloan Automotive Lab, the Department of Mechanical Engineering, and various student organizations. There were also fund-raising activities such as a driving competition held in cooperation with Dodge. But the members' dues and the one sponsor, Direct Tire Sales of Watertown, don't cover the cost of parts and racing fees, so the club is always beating the bushes for funds.

Even in Norman Marx's student days, when the sports car group had no car of its own, the shared know-how of a group of older students with an interest in racing was enough to alter permanently Marx's career path. He has nothing but enthusiasm for seeing the tradition revitalized and thriving. □



Working on the club's car in the Sloan Auto Lab is a ticket to hands-on track experience for members like Mark Sztenderowicz (below, left) and Eric Balles (above, right).



PHOTOS: DAVID GRAHAM, '87

16

We're grateful for several recent telephone calls. Grace and **Dan Comiskey** are still doing nicely. At the time of his call, Dan was not aware of **Nat Warshaw**'s death. Dan and Nat were very close prior to Nat's move to Florida. . . . Jane Richardson called to get the particulars on Technology Day. Her father, **Chet Richardson**, was anxious to make plans to attend. He was hoping to bring along his grandson, who is in the process of selecting a college or university for his undergraduate program. Chet recently celebrated his 90th birthday. He still sings in his church's choir, and the choir and congregation brought together approximately 250 relatives, friends, and local dignitaries to honor Chet on his birthday. Among other gifts, he received a portfolio of letters of congratulations from many of his friends. They also serenaded him with many songs.

As a result of our letter about the luncheon on Technology Day, we had a nice call from Anne, telling us that she and **Izzy (Richmond)**, along with their daughter, Jean, would be at the luncheon. . . . Frances called to say that **Paul (Duff)** was not feeling well and that they couldn't make a firm commitment to the luncheon but would make every effort to attend. . . . **Dina Coleman** responded with this letter: "I will not be at the reunion. Last August, a couple of days after my birthday party, I fell and made a three point landing on my head, elbow, and hip. I wound up with a hen egg on my head and below the right eye. The children insisted that I go to a doctor, who took a cat scan which revealed two hematomas at the front of the skull. He relieved these by boring a couple of holes in the top of my head. All this required a six-month period of convalescence. The children decided that a man of my age and position should not have to rely on taxi cabs, which I had done since I quit driving. So, at my expense, they bought a car and hired a chauffeur. He is the best investment they made."

Will Wylde pleased us with this note: "Since my family has a yearly reunion in western Massachusetts, my wife and I will be unable to be in Boston in June. I am looking forward to reading about the reunion in *Technology Review*."

Two others who had attended practically all of our reunions and class functions responded to a higher calling than our 70th. Both **Henry Shepard** and **Barney Gordon** died on May 14. Henry was a retired vice-president and sales manager for Stowe-Woodward Co., Newton Upper Falls, Mass. He was an inventor and held three patents associated with bowling ball manufacturing. He was also a longtime member of the Veteran Motor Car Club of America and owned and restored a number of antique automobiles. . . . Barney was president of the Massachusetts Knitting Mills for 50 years. He was also a founder of Brandeis University, the Albert Einstein College of Medicine in the U.S., and the Technion and the Weitzmann Institute in Israel. After retiring in 1970, he devoted himself to the supervision of the Barnett D. Gordon Family Foundation, which makes donations to support educational and medical institutions, including Brandeis University, M.I.T., and Philips Exeter Academy. We're grateful that we had the privilege and the pleasure of having them as friends for many years.

We regret to note the passing of **Edmund S. Parsons** at the age of 92 in Jamestown, R.I. in January 1986. May he rest in peace. . . . Please write.—**Bob O'Brien**, Acting Secretary, 28 Marinel Ave., No. Chelmsford, MA 01863

18

Class news is scarce. On May 3 your secretary participated in a program for M.I.T. Sustaining Fellows, celebrating the 125 birthday of our alma mater. It included a seminar on U.S. debt chaired by 1986 Nobel prize winner M.I.T. Professor Franco Modigliani, a most interesting and educational session. In the evening we were treated to a black tie dinner at the Hotel Meridien followed by a dance at the M.I.T. Athletic Center.

The spring meeting on May 10 of the Cardinal and Gray Society at the Endicott House in Dedham was another happy occasion. It was indeed a joyous event for about 80 M.I.T. alumni including spouses, all of whom graduated 50 or more years ago. The speaker was Professor Travis Merritt, director of the M.I.T. Humanities Undergraduate Office. What a change from our student days—today's undergraduates take as many courses in the humanities as in engineering and science.

We record with sadness the death of **Palmer Giles**, age 91, on March 17, 1986, at Hillingdon Ranch in Comfort, Tex. In his early career, Palmer was associated with his father's architectural firm in Texas and Mexico, continuing architectural work after the death of his father. Later he was safety engineer with Petty Geophysical Co. In 1947 Palmer returned to Hillingdon for full-time ranching. He is survived by his wife, Edith, a sister, and a number of children, grandchildren, great-grandchildren, and nieces and nephews.—**Max Seltzer**, Secretary, N. Hill Apt. B403, 865 Central Ave., Needham, MA 02192; **Leonard Levine**, Assistant Secretary, 519 Washington St., Apt. 15, Brookline, MA 02146

19

Alan McIntosh sends a happy letter which we are pleased to receive. We quote from Alan's letter: "Summer and fall were kind to me. I'm overwhelmed with family here in York (Pa.) nowadays and certainly enjoy it—one son, seven grandchildren, and five great-grandchildren. That crowd added to volunteer work at the hospital, York County Historical Society, the Exchange Club, and the local Barracks of Vets World War I keep me busy and happy. The only trouble—I'm the oldest member of the Exchange Club, the Historical Society, and near the top at the hospital. Looking forward to our 70th reunion!"

And may we wish you all a grand summer in this beautiful world. Again, our address for class notes is—**Bill Langille**, Secretary, P.O. Box 144, Gladstone, NJ 07934, (201) 234-0690

20

Welcome word, via phone, from **Buzz Burroughs** and **Frank Maconi** indicates that these spry gentlemen are hitting on all eight. Buzz has been active on the curling front and winning his share.

Larry Weymouth died in February. His home was in Clearwater, Fla. Formerly of New Jersey, he was an active and loyal member of our class. . . . **John Elliott** died on March 12. He resided in Newburyport, Mass., and is survived by his wife, Pauline. . . . **Myles Perkins** died last December. He lived in San Diego, Calif. at 6161 Madra Ave.—**Harold Bugbee**, Secretary, 702 Country Club Heights, Woburn, MA 01801

21

These notes are written before and will be published after our 65th reunion.

A phone call on April 18 from Helga and **Jim Parsons** told me they were back from a wonderful round-the-world trip. They will be at the reunion to tell us more about it. . . . A postcard dated April 17, 1986, from **Bob Miller** en route from San Juan, Puerto Rico, to Port Everglades said that he and his daughter Jo had been thoroughly enjoying their trip on the *Queen Elizabeth 2*, which started at Los Angeles. The highlight, said Bob, was going through the Panama Canal, where their 67,000-ton vessel was lifted 85 feet.

A letter in late April from class president **Carole "Cac" Clarke** reported that he and Maxine were also taking a tripm this one in reverse of the one **Bob Miller** took. They were leaving Port Everglades on May 10 on the *Rotterdam* and arriving at Los Angeles on May 25 to fly home. On their way to the reunion, they will stop at Manchester, Conn., to pick up **Helen St. Laurent**. Cac was recently honored with the presentation of an award from the local chapter of the D.A.R. in appreciation for a series of news articles to aid the chapter's fund raising for restoration of the Statue of Liberty.

Your secretary in late April spent a week on Cape Cod with his daughter Priscilla and her husband. The weather wasn't very cooperative, and we had four drizzly cold days. That meant only one picnic on the beach at Woods Hole and another picnic one day at Nickerson State Park near Brewster. While on Cape Cod we dropped in to see **Whitney Wetherell** in Harwich. He seemed to be well and enjoying a brief visit from his daughter Lois. We didn't see **Don McGuire** at Harwich Port but talked with him by phone and then later received a good letter from him. Don still plays the organ, and his hobby is making clocks. He buys the parts and assembles them. Don said he had been fighting cancer for the past five years; he's getting radiation treatments. If he can get a ride to Cambridge, Don will come to the reunion.

An Alumni Fund envelope had a message from **Goodman Mattelson**: "On the death of my wife Georgia, I moved to England to live with my daughter and son-in-law." I don't have his address.

Three deaths were reported this month: **Herbert W. Gwynn**, Naples, Fla., on December 29, 1985; **Paul A. Morgan**, Lawrence, Mass., on January 13, 1986; **Lawrence K. Burrell**, E. Bridgewater, Mass., on March 8, 1986. The sympathy of the class goes out to the families of these classmates.—**Sumner Hayward**, Secretary, Wellspring Housue E64, Wash. Ave. Ext., Albany, NY 12203; **Samuel E. Lunden**, Assistant Secretary, 6205 Via Colinita, Rancho Palos Verdes, CA 90274

22

Jane A. Steenstra, donor relations coordinator in the Office of Communications Resource Development sent to the class officers copies of the 1985-86 reports of the work by Professors Lynne Sagalyn and Cynthia Wolff, who currently hold the Class of 1922 Assistant Chair and the Class of 1922 Chair II, respectively. Professor Sagalyn for the past two years has been involved in a research study of downtown redevelopment. Professor Wolff reports that she has been engaged in writing a comprehensive and definitive treatment on the life and work of Emily Dickinson, perhaps, Professor Wolff says, America's very greatest poet. The manuscript, now finished, will be published in book form by Alfred A. Knopf in the fall of this year. Ms. Steenstra in her covering letter said, "We are grateful to you (the class) for supporting the Institute's purposes through the Class of 1922 professorships."

A note from **Bill Tripp** says that he is living in Sarasota and taking it easy. . . . **Theodore Shlikoff**, our oldest classmate—he was 98 last May 26 is now living at the Marshall Manor Nursing Home in Guntersville, Ala. He sends his regards to all of his old classmates. . . . **William Schulman**, Course X, age 85, died in Baltimore March 9, 1986. A note from Mrs. Schulman to the alumni office says that Bill was an active consultant, as a chemical engineer, up to the time of his death. . . . Word comes from Mrs. Keith P. Gould of Hamilton, Ontario of the death of her father **H. Ross Wiggs** on March 16, 1986, in Hamilton in his 91st year. Ross was an outstanding architect. He was a past president of the Council of the Province of Quebec Association of Architects, an associate of the Royal Canadian Academy of Arts, a fellow of the Royal Architectural Institute of Canada, and a fellow of the Royal Institute of British Architects, London, England. He is survived by his daughter, two granddaughters, and one great-granddaughter. Those classmates who knew Ross may recall his comments in the April 1983 issue of the *Review* in which he said, "To keep myself active (after retiring in 1966), I returned to my first love of painting in watercolors. It soon became a new life for me and a successful professional venture, as my work was well received by the public across Canada, in the United States, and elsewhere."

In addition to **Ross Wiggs**, we have recently lost another prominent architect, **Rudolf Hans Blatter**. He died April 8, 1986, in Sarasota at age 87. After receiving his degree at the 'Tute, he did graduate work at Princeton and then attended l'Ecole des Beaux Arts, Sorbonne in Paris. He was an army veteran of World War I, serving as a lieutenant in the field artillery. He worked in private practice and for the U.S. Treasury Department and the State Department, where he was involved in the design and construction of hospitals in countries that included Ecuador, Greece, and Honduras. He participated in the construction of U.S. defense sites and in the design work on the restoration of colonial Williamsburg, Va. He is survived by his wife Marilyn, three sons, a brother, and a sister. Our condolences are extended to the families of these deceased classmates.—**Yardley Chittick**, Secretary, Box 390, Ossipee, NH 03864

23

Robert H. Park has been elected to the National Academy of Engineering for major contributions to the theory and practice of electric-power system stability.

Charles Jackson died November 20, 1985. He graduated with our class in business and engineering administration. He was employed by the General Electric Co. in Lynn, Mass., for a brief period, then did method studies for the New England Structural Co. and cost accounting for the Boston Garter Co. He taught office practice at the Cambridge School of Architecture, then worked with Bemis Industries on their prefabricated houses. For ten years he was involved in various phases of the Consumer's Cooperative movement. He also helped develop a low-cost rural recreational facility with young people, who transformed an old farm house and its outbuildings into a modern summer camp to be owned and managed by themselves. For two years he went to the Wilfred Grenfell Mission in Labrador, where he and his wife taught school. He later joined the Quakers and with them tried to promote some of the social and economic reforms which he felt were desperately needed.

James A. ("Pete") Pennypacker died April 7 in a convalescent home in Clearwater, Fla. He graduated with our class in naval architecture and marine engineering. He began his professional career with the William Cramp and Sons Ship and Engine Building Co. in Philadelphia and later with the Marine Engineering Corp. in that city. In 1929 he moved to New York City to become assistant to the president of the National Council of American Shipbuilders. In 1936 he entered the Shipbuilding Division of Bethlehem Steel Co. in Quincy, Mass., becoming manager of engineering, from which he retired in 1964. Then he moved to Essex, Conn., and became affiliated with the Dauntless Shipyard. In 1966 he obtained a leave of absence to become special consultant to the Rand Corp. in Monica, Calif. He was a life member, Society of Naval Architects and Marine Engineers; director, Quincy YMCA, Quincy City Hospital, Thayer Academy, Braintree, Mass.; chairman, board of assessors, First Parish Church; and vice-president, Quincy Tennis Club. He was very active in class and alumni affairs, having chaired the 15th reunion and as member of other service committees, was assistant class secretary, then second vice-president, and member of the Alumni Council. He wrote a class song and many others, including one which he unsuccessfully tried to have replace the Connecticut State Song, "Yankee Doodle." He played the cello for many years.

Stewart Reimel died July 24, 1985. After studying the army ordnance course at the Institute, he continued his army career at various arsenals, maintenance, and ordnance centers. He received the rank of brigadier general in 1943, served overseas in Hawaii, Australia, and New Guinea, and returned to the office of Chief of Ordnance. He then joined the Ten Eyck-Wade Associates until 1961, when he finally retired. He was a Mason and Shriner, a member of the Army Ordnance Association, Delta Theta Fraterity, Army-Navy Club of Washington, D.C., and the Detroit Athletic Club.

Edmund Thimme died February 15. He graduated with our class in electrical engineering. He was associated with the Public Service Electric and Gas Co. of Newark for his entire career, working as executive engineer, superintendent, industrial relations manager, general superintendent, general manager, and assistant to the vice-president in charge of electric operations. After retirement, he pursued an active career in labor management arbitration, receiving appointments to the panels of the American Arbitration Association, the New Jersey State Board of Mediation, and the Federal Mediation and Conciliation Service. He was active in numerous social and service organizations. His hobbies were golf, bridge, and gin rummy.

Frank Travers died April 19. He graduated with our class in business and engineering administration. He began his career as marketing research manager for Eli Lilly and Co. at Indianapolis. From 1942 to 1945 he served in the U.S. Navy as lieutenant and lieutenant commander, Chief of Naval Operation, Washington, D.C. He continued his career with Lincoln National Life Insurance Co. of Fort Wayne, starting in investment research, and later became second vice-president in charge of securities for American United Life Insurance Co., Indianapolis. He retired in 1968 but continued as a consultant to the Finance Committee. He organized and became first vice-president of Scientech Club and was chairman of the finance subcommittee of the Indianapolis Scientific and Engineering Foundation, as well as being active in many other civic and service organizations.—**Richard H. Frazier**, Secretary/Treasurer, 7 Summit Ave., Winchester, MA 01890

24

We, the Boston Five (minus **Ray Lehrer** and **Dick Shea**, sunning in Florida) were pleasantly surprised April 26 by a visit from **Ed Abdun-Nur** on his return to Denver from a trip to Spain. He had not been in Boston for 62 years and immediately missed the xylophonic Harvard Bridge, now restricted to two-lane passenger car traffic, for structure safety. Experiences, limited by Ed's

schedule, were swapped with **Don Moore**, **Don Fife**, and **Russ Ambach** during an early supper at the Cambridge Hyatt Regency Hotel. Ed spent several days attending economic seminars and laboratories at the Institute, inspiring us with his philosophy of "live it up" in future years.

We attended a memorial service for **Herb Stewart**, who passed away suddenly in January. A church section was reserved for M.I.T. members. The altar was appropriately fashioned with a beautiful basket of red and white flowers—"Class of '24". The service was followed by a reception and collation for 200 guests.

George Harrington, a victim of cancer, passed away February 25, 1986, in a Salem, N.H. hospital. He did not opt for a degree at the Institute but spent four years in general science and then went on to take some courses in economics at Boston University. Jeff began his career as plant engineer at the Ford Motor Co. in Somerville, Mass., and after three years joined Hunt-Rankin Leather Co., Peabody, Mass. He became president and director until 1951, when he became general manager and vice-president of Wire Belt of America. He was also active in several realty companies and was an executive in five leather organizations. A licensed private pilot, during World War II he was a major in the Massachusetts Wing Air Patrol.

Our underground facilities in Virginia report that **Roland Black** has been playing tic-tac-toe with the medical profession. In the last 18 months, he has had three heart attacks, a quadruple bypass, aortic valve replacement, a prostate operation, and a hernia. When he gets home to 205 DeSota Dr., Richmond, VA 23229, he will be on exhibit as "M.D.D." (Medical Dollar Donations).

Don Moore, class president, has issued his undated timely plea for individual career experiences, sort of an autobiography, as a class record to inscribe the stories mouthed among us at reunions. As your secretary, I advise that just relaxing in a chair with pad and pencil, you can jot down memory highlights that bring surprises.—**Russ Ambach**, Secretary, 216 St. Paul St., Brookline, MA 02146

25

It is with sadness that I have to report the passing of **James H. Howard**, our class president. Jim died at his home in Cambridge, Mass. on April 15, 1986. A letter from Jim, Jr., '53, informed me that Jim had complained of a nagging cold in January. A visit to the doctor showed that Jim had suffered a "silent" heart attack of quite severe magnitude. After several weeks at the Massachusetts General Hospital, he returned home to recover further. However, his body slowly ran out of energy and, although he suffered no pain or trauma, he died quietly in his sleep. Jim did much for the class of 1925 and the Alumni Association. It was in recognition of his contributions that in 1980 he received the Harold E. Lobdell Distinguished Service Award. He served as a class officer over the years and did much on reunions. With the help of **Joe Martori**, he planned and organized the 60th reunion. Jim went with the Clifford Manufacturing Co. which after 1946 became the Control Products Division of Standard-Thomson Corp. He had many positions with the company and was vice-president and division manager at the time of his retirement. Jim leaves one son, James Jr., and a sister, Margaret A. O'-Brien, of Needham, Mass., three grandchildren, and a great-granddaughter.

The passing of three other classmates has been reported recently. **William Brown, Jr.** of Brunswick, Maine, died on February 2, 1986, at a Portland hospital. After graduating from M.I.T., Bill obtained a master's degree from Stevens Institute of Technology. For over 70 years, he was a summer resident of Bailey Island, Maine. From 1949 to 1971, he lived in Hastings-on-Hudson, N.Y. He was a prominent metallurgist in tungsten and molybdenum and also in continuous casting of aluminum. In later years he was associated with the Anaconda Co. During World War II, he provided tungsten and molybdenum wire for radio tubes for all branches of the armed services. He was a member of the American Institute of Mining and Metallurgical Engineers and a member of the American Society of Metals. Surviving are his wife of Brunswick; a son, William Thomas Brown III of Phoenix, N.Y.; three daughters, Mrs. George B. Wilkins of Lexington, Mass., Mrs. Judith Dickson of Anchorage, Alaska, and Mrs. Jackson M. Hensley of Taos, N.M.; eight grandchildren; and a great-grandson.

Ralph E. Lehan, the past president and treasurer of the James Lehan Ford dealership, died January 22 at South Shore Hospital, Weymouth, Mass., after a long illness. The firm started by his family was authorized by Henry Ford in 1904 and was the first licensed Ford distributor in the world. Ralph worked for the company from 1938 to 1959. Born in Stoughton, he lived from 1925 to 1937 in Warwick, R.I., where he was a teacher and varsity football coach at Warwick High School. He lived in Stoughton many years, moving to the home of his daughter, Jane E. Koch of Norwell, nine months ago. Husband of the late Ruth H. (Merchant) Lehan, he is survived by a son, James C. Lehan of Crownsville, Md., and four grandchildren.

Hector Harrison died in Oakland, Calif., on December 27, 1985. He lived in Walpole, Mass., for many years and was employed by the Hood Rubber Co. in Watertown. In 1950 he moved to California and was a stockbroker with Reynolds and Co. of Berkeley. He is survived by a brother, Arthur F. Harrison of Hilton Head, S.C. and eight nieces and nephews.—**F. Leroy "Doc" Foster**, Secretary, 434 Old Comers Rd., P.O. Box 331, North Chatham, MA 02650

26

Chia-Yang Shih regretfully declined our 60th reunion invitation. It would have been, he said "a precious opportunity for me to visit my respectful alma mater, to renew friendships among the 1926 classmates, and to learn the new scientific and technical developments in America." However, he was at the time giving a graduate-level course, Multipurpose Utilization of Water Resources, as well as heading up a research project, "Optimization Planning of Cascade Hydropower Development in the Langchang River in the Southwestern Region of China." When he retires, in about two years, he hopes to visit his classmates and friends in the U.S. He concluded his letter: "Wishing from the other side of the Pacific Ocean that the 60th Reunion of the Class of 1926 will reap a most prosperous harvest."

Robert W. Rogers reports that he is retired and trying to keep up with all the tasks and chores. Although he and his wife have had a number of medical problems this past year, they are now trying to resume their usual activities. They keep in touch with Doris and **Bruce Powers**.

We are sorry to report the following deaths of '26 classmates: **Thomas A. McLennan** of San Antonio, Tex., on January 26, 1986; **Philip Robinson** of Downey, Calif., on May 31, 1985; **Harry W. Pierce** of Woodstown, N.J., on January 9, 1986; **Charles C. "Rick" Rickerson** of Mars, Pa., on April 18, 1984; and **Helmut W. Geyer** of Mission Viejo, Calif., on January 17, 1985.

Rick Rickerson's sister-in-law, Virginia Koegel, writes to say that Rick passed away after a relatively short illness. He lived in Sherwood Oaks retirement community. . . . **Helmut Geyer** died at age 80. After receiving an S.B. in electrical engineering and an S.M. in fuel and gas engineering from M.I.T., he went on to an engineering position with Southern Counties Gas Co. of California and later became director of Robertshaw-Fulton Controls Co.'s research and development lab on the West Coast. He completed his career with Imperial Oils and Grease Co., a division of Beatrice Chemical, Beatrice Foods Co. in Los Angeles, where he traveled to Finland to teach procedures. An assistant to the president, he analyzed contracts, licensing agreements, patents, and regulations in foreign countries in all five continents.—*ed.* (**William Meehan,** Secretary, 191 Dorset Rd., Waban, MA 02168)

27

Thanks to **Michael R. Campbell** of Sydney, Nova Scotia, for a brief of his career. He received his S.M. in 1927 in Course X-A and was hired as assistant superintendent of the Open Hearth Department of Dominion Steel and Coal Co. After a couple of years in the early thirties as a professor of chemistry at St. Francis Xavier University in Antigonish, he returned to the steel company for 35 years. He retired in 1969 as technical superintendent. Mike was given a degree of doctor of law honors by the university and elected to the board of governors. He has five children. His eldest son, John Colin, received his S.M. from M.I.T. in 1957. Mike has offered old *Techniques* (1900 to 1905) to M.I.T., and your secretary will send them to the M.I.T. Museum.

Around the walls of the Faculty Club are hung 18 beautiful enlarged color photos of **Harold Edgerton**'s famous early flash pictures—the bullet passing through the King of Hearts and the drop of milk on a tin can are there among others. They were reproduced by Ten Eck Foundation. Thank you, Hal, for this beautiful showing.

Leroy G. "Lee" Miller and wife, Mildred "Shorty," write they are both 84 this year and are still quite well. They are active and enjoy their 50-acre tree farm—Christmas trees and much wildlife—in Rockbridge, Ohio. They want to come to our big 60th reunion.

Clarence L.A. Wynd, age 85, died on March 20, 1986, at his home in Pittsford, N.Y. When he retired after 40 years with Eastman Kodak, he was general manager of the Kodak Park Works, senior vice-president, and a director of the company. During his very active life, he had many humanitarian endeavors. He was vice-president and life trustee of the University of Rochester. He served on the education, investment, and building and grounds committees, and served nine years as chairman of trustees visiting committee of the medical center. He was founding Chairman of the board of overseers of Strong Memorial Hospital. Clarence was past president of the M.I.T. Alumni Association. He was a fine example of a successful M.I.T. engineer giving a large part of his efforts in his later years to public service.

George W. Brady died on February 10, 1986, in Washington, D.C. One of the few S.M.s in the new Course XVI in 1927, George was an active aeronautical engineer all of his life. He retired just a week before his death after almost 30 years as a consulting engineer in Washington. In 1958, after the launching of the Soviet satellite, Sputnick, he participated in the technical planning of the U.S. space programs. Among his assignments were work with launch vehicles and communication satellites and, during 1960, man-in-space analyses. He contributed to the STS-Space Shuttle program of NASA and helped design the configuration of the space shuttle. He was a member of the Cosmos Club and a fellow of the American Institute of Aeronautics and Astronautics and the American Astronautical Society. See also *Technology Review* June 1981. We extend our deepest sympathy to the widows of these two great M.I.T. men.—**Joseph C. Burley**, Secretary, RFD 3, Epping, NH 03042; **Lawrence B. Grew**, Assistant Secretary, 21 Yowago Ave., Branford, CT 06405; **Prentiss I. Cole**, Assistant Secretary, 2150 Webster St., Palo Alto, CA 94301

28

We have a very welcome letter from **Paul Ruch** who, in turn, had just received a note from **Ted**

Wood. It appears that Ted is thoroughly enjoying his retirement in Green Valley, Ariz.—he retired in 1970 after some 36 years of service with American Airlines. As for Paul, he had made the disappointing discovery that his 1928 *Tecnhique* was lost in his last move. We are trying to find a replacement copy or him. Paul's current interests are best expressed in his own words: "It may sound as though I don't have much to occupy my time. On the contrary, I am very busy (far from retired)—still deeply involved in long-range weather forecasting research. My son, who got his degree in meteorology at University of California, Los Angeles is handling the production of forecasts, and my son-in-law is directing sales. That leaves me free for research, which has been my principal effort for the past 20 years. Dot and I celebrated our 57th anniversary in April. Our daughter is in Pasadena and our son in Tustin—at the most, one and a-half hours from here via freeways. We are quite comfortable here in Leisure Village."

The spring meeting of the Cardinal and Gray Society was held at the M.I.T. Endicott House on January 11. Fortune smiled, and it was a gorgeous day. One of the ladies remarked that the gentlemen were "perfectly handsome in their white hair and bright red jackets." Our own class was very well represented by the attendance of Marjorie (Mrs. **John A.) Carvalho**, **Hugh Bean**, Frannie and **Jim Donovan**, **Bill Hall**, and Florence and **Walter Smith**. We had an outstanding speaker in Professor Travis R. Merritt, head of the Department for Humanities at M.I.T., who explained and discussed how M.I.T. is striving to turn out a well balanced product in its graduating classes. Just how much liberal education is best for M.I.T. seems to be an open question. Only a few opinions seem to have been expressed by our class members, although there was an excellent opportunity to do so in our 55th class book, *Thoughts and Sentiments*.

A note from **Chet Day** says, "We have left Maine for a new life-style—with Chet Jr. (M.I.T. '57, now with Bellcore) in the winter; summers in Pt. Maitland, Nova Scotia, where we use a beautiful cottage on the property of son Bill, professor in computer science at Memorial University, St. John's, Newfoundland. My 1979 mitral heart valve is still holding up, but other heart complications laid me low last winter—feeling better now."

Our most faithful of correspondents, **Bill Hurst**, has written in interesting style a good full review of his life and career. We intend to share this with you at an early opportunity. By comparison, all of our recorded reports from classmates have been little more than extremely brief sketches. Yet many of us have had full and eventful lives. Possibly Bill has opened up a new idea—how about more of you sending in a full account of your life and life's work that can be enjoyed by both your classmates and posterity?

William R. Grunwell died April 1, 1986. In our last set of class notes we mentioned that Bill had suffered a heart attack. Shortly after mailing in our notes, we received the notice of his death. Bill graduated in Course XIII, naval architecture and marine engineering, and this became his career field. Among the prominent companies he served were: United Fruit, Consolidated Steel and Bethlehem Steel. We extend our heartfelt sympathy to Bill's family.—**Walter J. Smith**, Secretary, 37 Dix St., Winchester, MA 01890

29

Sam Shaffer of Los Angeles, Calif., writes, "My wife Sybil and I are enjoying reasonably good health. I am still quite active—give my time to United Way agencies and do financial consulting for a few clients. The passage of time becomes evident when my granddaughters call me frequently on their problems." . . . **Earle Erickson** of Burlingame, Calif., writes, "My activites lately have been limited due to a recent operation from which I am recovering. Our big event of the year will be the arrival of a fifth great-grandchild. Best wishes and happiness to all." Earle's professional career was with W.F. Schrafft and Sons Corp. of Charlestown, Mass., as plant manager, treasurer, and vice-president from which he retired in 1959 and moved to California. He began a second career with the U.S. Post Office Department as West Coast chief engineer from which he retired in 1971. He served three years in World War II as commander, U.S. Naval Reserve. He has been active in class activities attending a number of major reunions including the 50th and the 55th. His hobbies include travel, photography, visiting art museums, acrylic painting, woodworking, stained glass work, gardening, cooking, and business and financial research. He walks three miles a day and does all maintenance repairs of his house including the grounds.

Kenneth G. Garside of Blue Hill, Maine, writes, "I doubt if you will remember me as I was a graduate student in Course X-A. However, that has been an important factor in my life. I am grateful that at age 81, and my wife Barbara at 73, are physically, mentally, and emotionally fit and able to enjoy this part of Maine, which is relatively natural." His hobbies include hiking, camping, and music. The Garsides have seven children and 14 grandchildren. . . . Professor **John Happel** of Hastings-on-Hudson, N.Y. sends his annual note: "I had a bad attack of the flu right after Christmas that hung on until our trip to the Caribbean. We are both feeling fine now. Dottie is very busy playing the violin with the Greenwich Symphony Orchestra (Conn.) and Lake Placid, where we spend our summer vacations. I am still hard at work at Columbia University and at the small company that I started when the New York University Engineering School folded up. I don't make much money, but it keeps me out of trouble. Late in May, Dottie and I are planning to go to Paris. I have a project there with a French colleague under the U.S./France scientific exchange program. We will also celebrate our 35th wedding anniversary there, as we did our first. Following the meeting, we are going to Budapest for a few days, where I will deliver a seminar and we will be guests of the Hungarian Academy of Science. Then on to Vienna for pleasure and sightseeing."

Richard E. Bolton of Westmount, Quebec, Canada, with whom I have been corresponding since our 55th reunion, where we all met him, sent me a note that I'd like to quote from: "Birthdays seem to be getting more precious, perhaps because there will be so few more of them for most of us. I expect to visit my daughter near Toronto and do some trout fishing in May, but I am never very far from home. Perhaps I may get to New England later on and to New Jersey to obtain a bit more information about my ancestors, which include such American notables as General Schuyler, Alexander Hamilton, and Colonel de Lancy (a Tory). By contrast, my paternal ancestors were a dull lot of farmers who wandered about central England to the extent of 40 miles in 300 years. With the coming of warm weather, I hope to get my wife Betty out in the grounds of the nursing home, where there are lawns, trees, and the Ottawa River flowing by. Her condition does not change much, but she is noticeably weaker than a year ago. I keep busy painting and think I can see some signs of improvement, particularly since I came home from my visit to Stockholm and England."

I have a note from **Hunter Rouse** of Sun City, Ariz.: "Many thanks for your cordial welcome to the ranks of the octogenerians of '29. Yes, I shall teach a graduate course at Fort Collins again this year, but only a reading seminar this time. By the way, as an 80th birthday gift, I had a textbook dedicated to me by a German author. Doi joins me in our best wishes to you, Helen, and to all my classmates." . . . **Robert S. Pride** of N. Palm Beach, Fla., and his wife Marion spent Easter with us as usual. They are well and happy to be in a temperate climate like Florida. Bob is very active taking part in the management of his condominium complex and doing all kinds of chores just for the pleasure of it. He also has a boat that he sails on Lake Worth. Marion has mastered the art of knitting, mostly sweaters and other objects, for relaxation. The Prides and the Dinjians attended a dinner meeting of the M.I.T. Club of West Palm Beach in Boca Raton, which was well attended, and we all enjoyed the evening program.

I have a note from **Bill Bowie** of Olmstedville, N.Y.: "Thanks for the birthday greetings, especially this big one which puts me in an exclusive company of octogenerians of the class of 1929. I am happy to be alive and well to reach it. I had a considerable amount of fun reading the poem, 'Life Begins at Eighty' (compliments of **Harold M. Weddle** of San Diego, Calif., published in the July 1985 issue of the *Review*). Sally and I are both well. We were so pleased to see you and Helen in September at M.I.T. during the National Alumni Conference, and especially at the time of your receiving the Harold L. Lobdel Award for your great contribution to the class as secretary for 16 years. Our zest for foreign travel seems to have been reduced by the many unpleasant events of recent times. However, we will still keep going around our own country. We hope to make a brief visit to Florida this spring. Would like to have a better view of the comet for the second time. Just to help you feel sorry for us, we had 33.5 inches of snow in the last week on top of the 12 inches (plus) on the ground, so we truly are in the winter wonderland. We had ten below-zero nights in the past month with coldest being 12 degrees below zero. Oddly enough, we enjoy it. Sally has three foxes that call regularly for handouts, and we have great fun watching the winter birds that visit our feed stations." The Bowies' did come to Florida and paid us a short visit on their way to Miami. We had a great reunion talking about the past, present and future.

Last October I was hit by a car one morning while bicycling in Hampton, N.H. This accident resulted in a minor concussion, badly bruised arms, and shoulders, and a big bump on my right temple. I was taken to the Exeter Hospital for treatment and x-rays while I was still unconscious. When I came to, the doctor informed me that all my vital signs were good, no bones broken, and that I would be alright in a few weeks. I was thankful and prayed to God for getting out of it so lightly. A few weeks after the accident, I noticed my eyes getting cloudy and blurred, and a visit to my eye doctor revealed that the concussion had caused the pressure of my eyes to go up from a normal 18-20 points to 44, a dangerous level. A succession of treatments, laser, eye drops, and pills in Arlington, Mass., and Boca Raton, Fla., brought the pressure down to the mid-20s, only to climb back again to mid-30s. A second laser treatment brought it down again, and currently the pressure is normal. One casualty—I won't be able to drive at night—I never liked driving at night anyway. Helen acts as my chauffeur during night driving.—**Karnig S. Dinjian,** Secretary, P.O. Box 83, Arlington, MA 02174

30

This month's notes are being written "Down Under," where Louise and I are enjoying a four-week visit to New Zealand and Australia, plus a three-day outbound stopover in Fiji and a five-day return stopover in Tahiti. We found New Zealand a quite lovely pair of islands thinly populated by people and thickly populated by sheep. The current ratio of sheep to people is somewhat greater than 20:1. In Australia the sheep/people ratio is much lower—only about 10:1. We have learned much more about the breeding, herding, and shearing of sheep and the marketing of ovine products than we really need to know.

Shortly before we left for the South Pacific, information forms came in from **Al Burling**, who now lives in W. Barnstable on the Cape, and **Bob Cook** who lives in Orange, Va. Al reports that Cape Cod has an active M.I.T. Club that is "for-

tunate to be close enough to Cambridge to attract knowledgeable speakers who keep us abreast of Institute activities." He and Grace attend and enjoy the Cardinal and Gray Society luncheons at the Endicott House in Dedham, Mass., where they usually meet the **Harringtons**, **Lathams**, **Pritchards**, and **O'Connors**, thus making the event seem like a mini-reunion. Al says that renovating his house keeps him busy.

Bob Cook worked as an architect with Bailey & Gardner in Orange, Va. from 1960 to 1983, specializing in library design. He is now practicing architecture under his own name and is also a compliance inspector for the Veterans Administration on homes being built with V.A.-guaranteed mortgages. In addition, he is a director of the James Madison Memorial Museum and of the Rotary Club in Orange. In recent years he has developed a novel structural concept, specifically, an array of notched panels made of foam-cored board, which can be used as modules in the construction of model buildings. He hopes to be able to commercialize this concept.—**Gordon K. Lister**, Secretary, 294-B Heritage Village, Southbury, CT 06488

31

Randy Binner called to say that he and Hope planned to attend our 55th reunion. . . . **John McNiff** writes, "Frances and I regret missing the latest three Cardinal and Gray meetings. We spent May touring Ireland and January visiting our daughter and son-in-law in San Jose, Calif., and touring the state parks here. But the Fall found Frances lying down while a broken ankle healed.

Ted Slack writes to say that, since his stroke, he now walks with a cane (20 yards at a time), which prevents his returning for our 55th reunion. He was a lieutenant commander in the navy before, during, and after World War II. After that, he was with the Broward County School Board for a number of years. He sends best wishes.

Helen and I just returned from a trip to Fiji, New Zealand, Australia, and Tahiti. Needless to say, we had a good time, meeting people and observing the scenery as well as Haley's Comet.

We have the following deaths to report. **David W. Bernstein**, who passed away April 17, 1986, lived at 530 Beacon St., Boston, MA 02116. David was 77 and retired head of Biltrite Rubber Firm, . . . **Jack T. Sherman**, of Sedona, Ariz., died December 24, 1985. . . . **George Bunker**, of Washington, D.C., retired chief of Martin Marietta, died November 5, 1985. . . . **Carleton B. Dix**, of Ashland, Mass., passed away December 14, 1985. **Joseph P. McBrien**, of Martinez, Calif., died December 18, 1985. . . . **Frances Crotty** died on May 20, 1984. . . . **Herbert Heller** passed away October 31, 1985. Our sincere condolences to their families.—**Edwin S. Worden**, Secretary, P.O. Box 1241, Mount Dora, FL 32757; **John Swanton**, Assistant Secretary, 27 George St., Newton, MA 02150; **Ben Steverman**, Assistant Secretary, 2 Pawtucket Rd., Plymouth, MA 02360

32

You can count on Evelyn and **Eric Newman** to be engaged in unusual and imaginative activities. Since our 50th reunion, they have purchased a 92-year-old victorian farm house, perched atop a bluff near Alton, Ill., which commands a spectacular view of the Mississippi River. The site is described by the *St. Louis Post Dispatch*: "From the heights, the river is an endless show. Bustling barges come and go; little towboats with horns, tooting, push fat cargos of grain, coal, and rock. A pleasure boat skitters noisily up the river, and a formation of honking geese fly south marking their progress against that of the river." The article continues: "Inside, Eric and Evelyn Newman's 'country' home is sparsely furnished, but cozy. Floors are of bare wood, walls and ceilings are white, and white wicker furniture is upholstered in subtle shades of brown and pink. The Newmans are a creative couple who always do whatever they do with a special flair. Mrs. Newman created some of St. Louis' most innovative fundraisers, from the Missouri Historical Society's annual flea market to the Arts and Education Council's *Camelot* extravaganza and the St. Louis Symphony's Gypsy Caravan. At present she is involved in the leasing project for Union Station. Newman, a lawyer and numismatist, is the nation's foremost authority on paper money from Revolutionary days.

"We wanted a place to get away from it all,' explained the Newmans, who bought the river bluff home about a year ago. 'You would be surprised how the number of phone calls one gets are cut down when the call is a toll call!' In one window, the Newmans have installed a hugh brass telescope on a tripod. Newman says that with it he can see across the marsh land all the way to the Missouri River banks."

I have received news that **Donatien L. Dionne** died August 31, 1985, in Norway, N.H. He grew up and lived his life in the Maine and New Hampshire areas. He was manager of A&P stores for many years, and upon retiring he opened his own market. He is survived by his wife, one son, and two daughters.

Wyman P. Boynton wrote me concerning the demise of his friend **Rufus Dryer**. His obituary appeared in a past issue of our class notes. The M.I.T. Alumni Association has received word that **James M. McMartin** died on March 24, 1986, in Sarasota, Fla.

I want to add two more that were inadvertantly left out of our class list of sustaining fellows. They are Mr. and Mrs. **Albert J. O'Neill** and Dr. and Mrs. **G.H. Dietz**.

The Cardinal and Gray Society had a May meeting in which Professor Travis Merritt spoke about Humanities at M.I.T. Our class was very well represented by the following: Eleanor and **William Bannon**, Phylis and **Donald Brookfield**, Ruth and Dr. **Albert Dietz**, Helen and **Albert O'Neill**, and Lois and Al Dunning.

Phil Bensamin is going to the hospital on May 13, 1986, for prostrate and bladder attention. We wish you a rapid recovery. . . . **Don E. Corson** tells us that he and his wife are enjoying good health. He is retired but gives a good deal of his time to caring for his shrubbery and flowers.—**Melvin Castleman**, Secretary, 163 Beach Bluff Ave., Swampscott, MA 01907

33

We used to say "another country heard from." This month we have, courtesy of the Alumni Fund, a short note from **Charles Quick**, electrical engineer, who writes from Traverse City, Mich. He and Lynn enjoyed the 50th reunion, Technology Day, and Chatham Bars. They hope to see us all again in 1988. He doesn't say what he's been doing during the past 50 years, but he has been asked.

John King, Course I, writes that the stamped self-addressed envelopes did him in, and he answered. For many years, he worked with Master Builders Co. of Cleveland on specialty concrete problems all over the U.S. and most countries of the world except China and Russia. He was the working member of their family, while Mary was the political member. For 23 years she was a member of the Cleveland School Board. Specialty concrete doesn't sound glamerous, but our folks used Ed's products; when one needs them, nothing else will do. A new cataract implant helps him a lot, as a good number of '33ers know. Once in a while he attends Cleveland alumni affairs but doesn't see members of 1933 often. He corresponds with **Edward J. Kratt**, who reports they celebrated their 45th anniversary. At Chatham next time, let's make some mention of our long-married classmates.

Frank Hatch of Burlingame, Calif., didn't reply to his Christmas card. . . . **George H. Isserlis** passed away this past spring. He was a chemist, living in New York City—and that's all we know about him. . . . **Ed Wemple** called when we were out of town and left a short message on the "box," followed by a brief letter. He lives in Darien, Conn., and occasionally travels to South Carolina, changing planes in Charlotte. We hope to get in some talk on his next visit. He is retired but goes to his son's office a few mornings a week. He says it is "nice to have something to do with little responsibility."

Bob Dobson fell from grace as a civil engineer and became a contractor. He and a group flew from Lincoln, Nebr. to Kiawah Island, S.C., to play golf on the way to the Masters Tournament. He remembers that he and **Cy Hapgood** drove in a Model A from Boston to Los Angeles for the 1932 Olympics—undoubtedly one of the greatest safaries of all times! . . . **Charles MacMillian** postcards this year that he worked for the SAE in Detroit, mostly designing automotive equipment. He spent most of World War II in the Pentagon, coming home as a full colonel. He retired in 1969.

Fred Murphy sends along a copy of the M.I.T. *Senior Superheater* for graduation 1933. It was drumming attendance for the graduation events. Starlita played at the prom, which was held at the Bradford. **Dick Morse, John Longley**, and others were selling tickets. **Pierre S. DuPunt** was mentioned as buying a new hat. **"Doc" Rowe** was noted as undoubtedly the most important member of any committee, and **Bob Holt** had been missing for three weeks and the *Superheater* was seeking information. The going price for admission to all graduation events was $9.75 in 1933!!!

Murphy said last spring that he and Ann were planning to attend an M.I.T. banquet. If there was any news, it didn't filter down this way. Eighteen months ago your secretary wrote asking for information about our co-ed members. There were too few answers. . . . where are you ladies?

Some months ago **John Longley** said he was doing some cross country skiing. He broke a fibula in his right leg, but summer has come and he is well again. He said "end of paper," and so it is.—**Beaumert Whitton**, Secretary, Cottage 112, Sharon Towers, 5150 Sharon Rd., Charlotte, NC 28210

34

Let me take care of our losses first; we have two more this month. The first is **George Siegel**, who died in Longmeadow, Mass., on February 9 of this year. Unfortunately, beyond the fact that he is survived by his widow Ruth, I have no further information.

The second loss is that of **Clifford Hentz** of N. Billerica, Mass. Mr. Hentz died last December 16 and certainly must have been one of the older members of our class, having been born in 1900. According to the newspaper obituary, he had been a member of the M.I.T. faculty for a number of years and then worked for the Gamewell Co. in Newton Upper Falls for 20 years prior to his retirement in 1965. A widower since 1981, Mr. Hentz is survived by three sons, two daughters, and a number of grandchildren and great-grandchildren.

To the families of both these classmates, I would extend sympathy from us all.

Alumni Fund notes are a little more plentiful this month. **Raymond Holland, Jr.** writes, "President of the Holland Corp., currently working mainly on wind power technology, trying to get overall costs down to a competitive level relative to coal and nuclear electric power." . . . **Art Esslinger** says, "Have been retired for 15 years and have enjoyed every minute of it. Am president of the Ft. Totten (L.I.) Retired Officers Club, and this, with hobbies and traveling, makes for a very full life. Have been married 46 wonderful years."

Another traveler is **Irving Kusinitz**, who notes, "Marion and I are heading for what should be a

very exciting trip starting at the end of March, visiting the West Coast of South America, with emphasis on the Galapagos Islands and Machu Picchu in Peru.' . . . **Warren Kunz** writes, "Still delighted with our new (three years) location in Deltaville, Va.—21 marinas in one small town! We still cruise and have our small ketch at our own dock. Would like to hear from and see friends. Routes 17 and 33 get here from Interstate 95." (Deltaville is not far from Williamsburg and Yorktown. Should anyone be interested, Warren gives his telephone number; (804) 776-9931.)

This is written in May. Lots of you will be traveling this summer, so drop me a line about your trips. My own are starting May 30, when I leave on the two-week Quarter Century Club trip to Vienna, Saltzburg, Munich, and a trip down the Rhine. So much for what I think about Mr. Qaddafi et al. So, in self-defense, you'd better write about your own travels!—**Robert M. Franklin**, Secretary, P.O. Box 1147, 620 Satucket Rd., Brewster, MA 02631; **George G. Bull**, Assistant Secretary, 4601 N. Park Ave., Apt. 711, Chevy Chase, MD 20815

35

My correspondence folder is just about empty—so let's have a little action please. I have a short note from **Baldwin Anciaux** by way of the Alumni Fund: "Moved to Seattle in 1941. Engineering in shipyard during the war. Direct sales principally in education field. Retired in 1980."

Friends of M.I.T. Crew had an open house at the Pierce Boathouse on Saturday, May 3, during the crew races against Wisconsin and Dartmouth. It was fun to watch the races in which M.I.T.'s heavy varsity crew edged out Dartmouth while losing to Wisconsin. I introduced myself to the M.I.T. stroke after the race, congratulating him on the race, and told him that I occupied his position 51 years ago. He looked startled, so I explained we had our 1935 crew on the river last June and the boat went well. He's probably still wondering how we did it. M.I.T.'s heavy varsity previously beat Columbia and the Coast Guard this season.

I am sorry to report to you the death of **Samuel J. Whitmore, Jr.** in Santa Monica, Calif. on November 26, 1985. I shall be writing my next notes after I return from a trip to Alaska in mid-June and hope to find some mail from classmates by then.—**Allan Q. Mowatt**, Secretary, P.O. Box 524, Waltham, MA 02254

36

Again these notes have to be submitted prior to our 50th. When I told the committee, with one voice they said, "Can't you just tell them it was a wonderful occasion!" Well?

I do have some less happy news this time: **Leonard Blakely** died on April 23 after a long battle with cancer. His wife, Orene, had predeceased him in 1980. He came to the Institute from Newburyport, Mass., having attended Northeastern before entering M.I.T. Following graduation, he moved to New Jersey and had lived in Towaco since 1947. He was employed variously by the Best Manufacturing Co., AT&T, Boonton Radio Corp., and Tel Instruments, before becoming a partner and co-founder of L&M Associates. He is survived by a son, Daniel, of Gulfport, Miss.; a daughter, Jane (Mrs. Alvin Sanoff), of Bethesda, Md., six grandchildren; and a sister, Louise Gingrande who wrote to tell us of this loss. To the entire family go our thoughts and expressions of sympathy.

I also received a note from Mrs. **Kenneth Bullington** of Colts Neck, N.J., telling of the death of her husband on May 30, 1984. He is listed in the alumni directory as a member of the class of 1937, at which time he received his S.M. in electrical engineering. He spent many years at various locations with Bell Telephone Labs from which he eventually retired. He evidently felt a kinship with our class. His widow wrote that he would have enjoyed our 50th. Frances Bullington's address is 36 Glenwood Rd., Colts Neck, NJ 07722.

In closing, let me tell you that the next notes should be full of reunion news!—**Alice H. Kimball**, Secretary, P.O. Box 31, West Hartland, CT 06091

37

Charles W. Gadd, Hendersonville, N.C., been named a fellow of the American Society of Mechanical Engineers (ASME). Fellow status is conferred upon a member with at least ten years active engineering practice who has made singificant contributions to the field. Charles retired from the Biomedical Science Department of General Motors Research Laboratory, Warren, Mich. in 1976. He began his work with GM in the fields of stress analysis, vibration, materials strength, and acoustics in new products. In the mid fifties he supervised biomechanics and auto crash protection research and development at the laboratories. He was a recipient of the U.S. Department of Transportation's Award for Excellence in Auto Safety Development. He is a former member of the Society of Automotive Engineers, Society for Experimental Stress Analysis, and the International Standards Organization.

Josiah Heal, Longboat Key, Fla., (retired June 1977) writes, "We're looking forward to seeing our classmates next year at the class reunion. Enjoying retirement on Longboat Key in the winter and Acton, Maine., in the summer. Decided to take up oil painting this spring. If Churchill and Eisenhower could do it, why not me? Have been doing a lot of singing in the Florida and Maine churches."

Milton Lief, St. Louis, Mo., reports he is "still working every day for Falcon Products, Inc., St. Louis, as special projects engineer and corporate quality control manager." His volunteer work includes: chairman of Olivette Land Clearance Authority, chairman of Olivette Public Housing Authority, vice-president of West St. Louis Country Rotary Club (26 years of perfect attendance), and charter member and board member of Congregation. He spent two months in Newport, Tenn., setting up a new facility and still has his 1984 and 1985 vacations to take. Wife Rose's main interest is taking care of three grandchildren living with them. Milt writes, "Still working very hard. Looking forward to our 50th next year. Hope to be in Boston area before that. Could not celebrate my birthday until I returned from Tennessee. Am looking forward to a round-the-world trip when I can find time (have already earned my ticket)."

Robert Thorson, Medford, Mass., writes, "Back from Florida—weather down there was not great this year, but still had a good vacation. Had dinner with Ruth and **Phil Peters** at their son's condominium at PGA—beautiful house. At the dinner were Janet and **George DeArment**, Alice and **William Johns**, as well as Peggy and **John Fellouris**. All were in good health and enjoying themselves. Spoke to **Joe Smedile** on the phone. Martha had just come from the hospital, but he assured me that everything was OK."

William C. (Bill) Wold, W. Ossipee, N.H., retired in 1968 as president of William C. Wold Associates (transport aircraft sales and leasing). He is now semi-retired working on real estate investments and is president of Air Land Corp. His hobbies and volunteer work are swimming, bridge, chess, (tennis, until heart attack last year). He is presently teaching a 27-year-old illiterate to read, write, and calculate. His travels have taken him all over Europe, Pakistan, Hong Kong, Tahiti, Somoa, Fiji, a circuit of South American countries, and this year to St. Croix. Wife Louise Saunders' main interest is psychotherapy. Louise returned to school at age 51, completing her B.A., and went on to obtain a master's in counseling psychology at age 54 (1978). Bill writes, "Had coronary artery bypass in 1972 and in 1978, with aortic valve implant, then coronary artery angioplasty in 1985. Still can swim, walk two miles, and travel."

I regret to report the death of **Melville E. Hitchcock** of Ivoryton, Vt., on March 9, 1985, and **David C. Hill** of Flintridge, Calif., on May 17, 1984.—**Lester Klashman**, Assistant Secretary, 289 Elm St., Apt. 71, Medford, MA 02155; **Robert H. Thorson**, Secretary, 506 Riverside Ave., Medford, MA 02155

39

Our '39ers are touring. Marie and **Pete Bernays** are in Columbus after five weeks in the South Pacific, where they stopped over in Australia, New Zealand, and Tahiti. After resuming activities at Chemical Abstracts, Pete reports no problems attributable to either jet lag or young ladies in Tahiti.

Laia and **Dick Hanau** joined Pete and Marie for that South Pacific junket and are at home again in Patterson, N.Y. . . . Anne and **Ben Howes** established retirement living, and they do volunteer hospital work in Bloomfield, Conn. They expect to summer in New Hampshire. . . . Lolita and **John Renshaw** stopped mining gold in Alaska to bicycle and swim in Hillsboro, Calif. John leaves bike path and poolside every now and then to help the president via the American Council for Capital Formation.

Jean and **Sid Silber** interrupted real estate developing to travel to Japan at just the right time: in the autumn to see the unique chrysanthemum displays and the mountainside leaves turning color. On another trip they sailed a 36-footer five days on open ocean from England, via Channel Islands, to the Normandy Coast of France. Wonder what took them so long—we made it in one day about 42 years ago! . . . Aletta and **Bob Touzalin** enjoyed skiing again at Aspen. After suitable rest-up at their Florida base, they expect to travel in Britain and Ireland for five months. . . . Eleanor and **George Beesley** will travel in China during the coming summer.

We were saddened by news of the death, on February 17, 1986, at Watertown, Conn., of **Robert S. Cady**. There were no details.—**Hal Seykota**, Secretary, 1415 Seacliff Dr., N.W., Gig Harbor, WA 98335

41

Robert M. Fano, professor emeritus of electrical engineering, discussed lifelong education for engineers at a conference at Texas A&M University earlier this spring. . . . **Albert L. Bensusan** retired as vice-president and treasurer of a jewelry manufacturing company. He says, "Clare and I have sailed our new Nonsuch 30 sailboat down through the innercoastal waterway into Florida. Now back in Rhode Island, I am taking classes while Clare is getting her degree at the University of Rhode Island. . . . **Walter L. Treadgill** of Baton Rouge, La., died the week of March 17, 1986. . . . **Arnold S. Mengel** of Vista, Calif., died January 1, 1986, from injuries resulting from an auto accident on November 21, 1985. Our condolences to his wife Mary.

Robert Arthur Mallory died November 25, 1985. He was a native of Philadelphia, Pa., and lived in Palmira before moving to Branchburg 36 years ago. For the last 41 years, he was a research chemist at Ortho Pharmaceutical. He was active in the First United Methodist Church of Somerville, N.J., and a loyal member of the church's choir. He also served the State Board of Education and was on the Branchburg and Somerset County Boards of Education. His wife Naomi and four daughters survive him.

The first holder of the Class of '41 Professorship is Dr. Philip A. Sharp, a molecular biologist, who directs the Center for Cancer Research. Dr. Sharp helped establish a very popular undergrad-

uate biotech laboratory course and currently teaches courses in virology and cell biology. The center for cancer research emphasizes research in the molecular aspects of cancer and cell biology. The staff of this important center numbers approximately 175 persons.—**Joseph E. Dietzgen**, Secretary, Box 790, Cotuit, MA 02635

42

Retirement continues to be the name of the game. **Marsh McGuire** says that he is enjoying life, is in reasonably good health, is dabbling in real estate development, and is looking forward to the 45th. . . . **Donald Greatorex** reports that he has retired after 35 years with Pratt and Whitney and is enjoying it. . . . But Rosett's Grand Prize in the Retirement Sweepstakes goes to **Jack Crandall**, who spent most of his first year of retirement on business trips and on having eye surgery. That sounds like our candidate for a consolation prize!

George Toumanoff recaps his second year of retirement with a rundown of his work in the International Measurements Confederation. He is president of the organization with international headquarters in Budapest. It makes for a lot of interesting travel, and George gets to use his fluent Russian and passable French. On the side, he plays tennis, sails, rides horseback, and just renewed his private pilot's license. . . . **Art Power** is still at his recently established consulting business specializing in chemical process/project engineering in developing/emerging biochemical processes. . . . Lee Hurley Bloom, '40, recently recruited **Bob Greenes** and **Alan Katzenstein** for a United Nations workshop to look into the UN's role in peaceful and in military uses of space. . . . **Al Hayes** is already planning for our 45th reunion and asked the date. Technology Day 1987 will be on June 5. The Pops Concert will be on the 4th, and the program will run through the 7th. So let's all start planning.

Charles Stempf, **Hank Henderson**, **Frank Seeley**, **Paul Bruckmann**, **Bob Rines**, and apparently some other Chi Phis and sundry hangers-on planned (and probably had) a mini-reunion at **Bob "Hawk" Shaw**'s farm in New Hampshire early in May. If any of them recover enough to pen a reasonably coherent report of the doings there, it will appear in all its lurid detail in next month's class notes.—**Ken Rosett**, Secretary, 191 Albemarle Rd., White Plains, NY 10605

Reporting from China: A World Not So Far Apart

They had as many questions about M.I.T. as their visitors had about China, and they cherish every memory and every keepsake of the Institute. But their world in the Peoples Republic of China seems astonishingly like ours in the United States: one is teaching the management of large industry, another works in foreign relations for the Shanghai Federation of Industry and Commerce, a third had just finished writing a Chinese-language text on "Polymers in Microelectronics." . . .

. . . Before travelling to China a year ago, photographer Owen D. Franken, '68, asked several alumni in Shanghai for their help: "I am especially interested in photographing what is happening in China in technological fields," he wrote. As a result, Franken was plied with uncounted cups of tea and several home-cooked meals while being shown scores of computers and even a computer bookstore in the heart of Shanghai where machines and software were on sale.

To supplement Franken's pictures, *Technology Review* solicited from these alumni the brief comments on their interests and activities that appear with each picture to the right. □

43

I have scooped the *Review*'s clipping service on news printed in the latest issue of *Tech Talk*. Class of 1943 Career Development Professor **Sylvia T. Ceyer** has been selected to receive a $25,000 Sloan Research Fellowship, which is awarded to young scientists of "extraordinary promise." We all can feel very gratified that our professorship is held by such an outstanding person.

From IEEE comes the announcement that Dr. **Richard B. Adler** has won the society's 1986 Education Medal "for leadership in engineering education through teaching and textbooks in semiconductor electronics and electromagnetics." Richard is associate head for Electrical Science and Engineering in M.I.T.'s Department of Electrical Engineering and Computer Science.—**Bob Rorschach**, Secretary, 2544 S. Norfolk, Tulsa, OK 74114

44

Herbert J. Cunningham writes that he is "too young to retire!" He is "still involved in flutter analysis and unsteady aerodynamics with NASA at Langley. Only 40 years service." . . . From **William C. Cooley**: "I'm now an associate professor in the Electrical and Computer Engineering Department of George Mason University in northern Virginia. As the only mechanical engineer on the faculty, I'm being retreaded to teach FORTRAN, computer aided design, etc." . . . **Chet Woodworth** reports his retirement from Monsanto on December 1, 1985, via the "golden handshake." During a vacation in Florida in February, he ended up in the hospital for an operation. As of this writing, he is still recuperating down there but expected to be back home in May and hopes to continue with consulting.

K. Thomas Momose retired from Gilbert/Commonwealth International, Inc. (a subsidiary of Gilbert Associates, Inc.) as director of projects, Japan, effective December 31, 1985. We regretfully report that **Robert B. Schick**, president of Utah Dynamics, U.S.A. in Salt Lake City, passed away March 6, 1986. Unfortunately, no further information was received.

Your faithful reunion committee is seriously considering another mini-reunion some time before the big 45th. There are several possibilities, including **John Burdakin**'s offer for setting up a Michigan get-together and, recently, a second offer from the **Hammarstroms**, encouraging a West Coast reunion. A good working committee, plus a year of careful planning, are prerequisites, so we will do our best to pursue this further. Any feedback will be welcome.—Co-secretaries: **Andy Corry**, Box 310, W. Hyannisport, MA 02672; **Lou Demarkles**, 53 Maugus Hill Rd., Wellesley, MA 02181

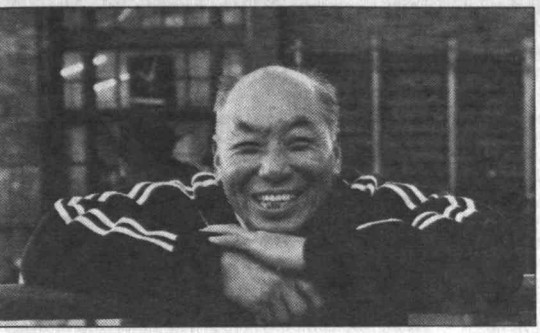
46

All the input I've received this month you could fold in a blade of grass (as Raymond Chandler would put it). Anyhow, I did get a brief, interesting note from **Stu Edgerly**, who is lolling in the Miami sun after retiring last October. He'll definitely be at Stratton Mountain to greet us, as will his wife Susan (of the Estey Organ family from Brattleboro). Remembering Stu's regaling tales at the 35th, I'm looking forward to some more. For that matter, I'm looking forward to seeing a lot of people who were at the 35th. Among them will be **Ned Tebbets**, who called me at my office (brave man, indeed) in conjunction with the class gift telethon.—**Jim Ray**, 2520 S. Ivanhoe Pl., Denver, CO 80222

47

Enthusiasm and plans are growing for our 40th reunion bash. There will be a full schedule of events centered around Technology Day. Following this, we are planning a long weekend excursion—the thinking now is southern Vermont—to continue the camaraderie in a more relaxed atmosphere.

Contributions continue to come in for our Class



I have retired from my active duties at the Shanghai Electrical Apparatus Research Institute and am now vice-president in charge of foreign relations at the Shanghai Federation of Industry and Commerce. The federation is actively engaged in bringing foreign businessmen and investors to do business with China, and my present position is far more demanding than managing purely technical affairs at the Research Institute."

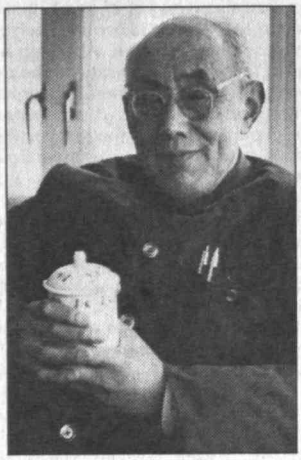
—Charles Y. Wang, '39

After more than 33 years in the shipbuilding industry, I decided in 1979 to teach systems engineering and large industry management to engineering and social science graduate students. I believe these are the greatest needs for China's economic reform. Many American friends have sent a lot of teaching materials. They really keep me an evergreen plant with shiny leaves."

—Chien Y. Chien, '46

Having returned from M.I.T. to China in 1946, I became professor of chemical engineering and applied chemistry at Jiao Tong University in Shanghai. My present interest is in the field of applied chemistry in electrical and electronic engineering."

—Chen C. Ku, Sc.D. '45



My effort continues, in collaboration with the M.I.T. System Dynamics Group, to promote wider understanding of system dynamics. I have travelled to the United States three times since 1980 to visit managers, economists, professors, and engineers and to get updated information, especially in telecommunications and nuclear energy, to help modernize China."

—Ching T. Yang, '30

PHOTOS: OWEN D. FRANKEN

of 1947 Professorship. We expect to announce that our goal has been reached next June. This goal is easier to reach than you might think. Your generous pledges made now will count towards the goal and may be paid over the five years following the reunion.

Bob Athow called when he was in town visiting. . . . **Roy Oberholtzer** writes that he is in polymeric materials engineering in the avionics group of Rockwell International. He is a member of the Rockwell Material Sciences and Engineering Panel; chairman of the ASTM Section D09.12.14 on EMI Shielding with Non-conductors; president-elect of SPE, Eastern IA chapter; and a member of the local high school's "Engineering Career Guidance Committee."

From the Naval Sea Systems Command (NAVSEA) comes news of Rear Admiral **Wayne E. Meyer**'s retirement last December after 42 years of naval service. Wayne was a leader in the development of the navy's revolutionary Aegis weapons system and served until recently as deputy commander for weapons and combat systems at NAVSEA. Aegis, installed on cruisers and destroyers, protects aircraft carrier battle groups. His shore assignments included staff director, Destroyer Force, Atlantic; director of engineering, Naval Ship Weapon Systems Engineering Station, Port Hueneme, Calif.; manager, Aegis weapons system, Naval Ordnance Systems Command; project manager of surface missile systems; and, in 1974, the first director of surface warfare. After his selection for flag rank in 1975, he assumed duties as project manager, Aegis shipbuilding. In 1983, he became deputy commander, weapons and combat systems, Naval Sea Systems Command. I guess it's no wonder that he had no time for *Tech Review*, until now.

Dick Turner died in April of acute leukemia, after an illness of only four months. He was a member of the Numerical Control Society and the Society of Manufacturing Engineers, vice-president of his Boy Scout council and recipient of a number of scouting honors and awards, clerk of the session of his church, educational counselor for M.I.T., and a member of several lodges. He was an employee of Westinghouse Electric Corp. for 38 years. He is survived by his wife, Doris, to whom we are indebted for this information, his mother, two sons and their wives, and a granddaughter. Doris writes that they had been looking forward to our 40th reunion next year. You may write to her at 930 Bowman Rd., Elmira, N.Y.

From the notes of the class of '46, in case you missed it: **Russ Dickey** died in January in West Covina, Calif. "Russ, a Course VI'er out of Pawtucket, migrated to the West Coast in the early fifties and went to work for General Dynamics, Pomona. He had been ill for some time prior to his death. He is survived by his wife, Stella, and four sons. . . . If you would care to write, Stella can be reached at 639 Prospero Dr., West Covina, CA 91791."

Keep the news coming, please.—**Virginia C. Grammer**, Secretary, 62 Sullivan St., Charlestown, MA 02129

48

Eph Sparrow is professor of mechanical engineering at the University of Minnesota in Minneapolis. Recently Eph was elected to the National Academy of Engineering. This honor recognizes his outstanding, prodigious contributions to heat transfer through analysis and experimentation, and his superlative teaching. During the 27 years at University of Minnesota, 165 theses were completed under his direct supervision. He has published over 550 papers himself. His wife, Ruth May, said Eph likes to organize and to complete things today. Eph was like this at M.I.T. also. He was 19 when he graduated in February 1948. He considers 110-hour work weeks "normal." This year Eph is at the National Science Foundation in Washington as program director of thermal systems and engineering. He returns home every other weekend to supervise his thesis students. A while ago he spent two years in Brazil, and during a trip to China he took off his jacket and

worked in the labs with the staff.

After Eph's secretary of 27 years retired, his wife, Ruth May (better known as Pooh), took over all his secretarial work. Although her job involves no financial compensation, she receives much appreciation and thanks for her help. Their daughter, Rachael, is married to a professor at Purdue. Eph and Pooh enjoy the many cultural opportunities in the twin cities area. Eph welcomes visitors or calls in Washington at (202) 357-9606

Bob Sandman, chairman of our 40th reunion committee, has mailed you a questionnaire about planning the program for our 40th reunion. By the time you read this, Bob should be tallying the responses.

Denny McNear, chairman of our reunion gift committee, has asked committee members to begin personally soliciting classmates to support M.I.T. The committee is ready to start moving now that many classmates have taken part in several meetings to prepare lists of prospects. All members of the committee are solicitors, and over the next two years everyone will be solicited.

Nilo A. Lindgren and **Karl L. Wildes**, '22, have written a fascinating book, *A Century of Electrical Engineering and Computer Science at M.I.T., 1882-1982*. They credit Professor Dugald Jackson, who headed Electical Engineering from 1907 to 1935 with introducing research into the work of engineering professors at M.I.T. Professor Emeritus Karl Wildes' clear memory extends from the oral traditions of the 19th century to M.I.T. today. The book describes how the research laboratory in electronics blossomed, yielding everything from telemetry to information theory to modern linguistics and artificial intelligence. The acoustical labs turned into Bolt, Barenek, and Newman and a hundred other startups. In the 1970s electrical engineering and computer science joined forces to engineer large scale integration of devices on one semiconductor chip. Once again M.I.T. changed itself and developed a way to dominate in an area of technological achievement.

Harrison Rowe is professor of electrical engineering at Stevens Institute of Technology. Recently his proposal to do research on "Radio Imaging of Launch Vehicles and Payloads" was selected for funding by the Defense Department's Office for Innovative Science and Technology. The Department of Defense received 3,000 proposals and is making only a limited number of awards. Before joining the Stevens faculty in 1984, Harrison was at Bell Labs.—**Marty Billett**, Secretary, 16 Greenwood Ave., Barrington, RI 02806

50

Kenneth H. Olsen, founder and president of Digital Equipment Corp., was chosen to receive the newly-established Engineering Leadership Recognition from the Institute of Electrical and Electronic Engineers, Inc. The recognition is given to individuals whose engineering managerial leadership has resulted in outstanding achievements, contributions, or service to the field of electrotechnology. Ken was also chosen to receive the New England Award presented annually by the Engineering Society of New England.

Joseph W. Trombly, Jr., retired in August 1985, after 34 years with McDonnell Douglas Corp. in St. Louis, Mo.

We regret to announce the deaths of **Ralph E. Wolfe** and **Charles P. Wurth**, who was the delegate from M.I.T. for Luxembourg.—**John T. McKenna, Jr.**, Secretary, 9 Hawthorne Pl., 10-H, Boston, MA 02114

51

John C. Richardson took early retirement this year from the Linde Division of Union Carbide, after 34 years of engineering management positions and is looking forward to spending the summer at their Chautauqua Lake lodge. . . . **William A. Krivsky** was recently awarded the Robert E. McConnell Award by the American Institute of Mining, Metallurgical, and Petroleum Engineers for his pioneering work in the development of the argon-oxygen-decaburization process, resulting in higher quality stainless steels and the conservation of minerals. That process was invented and patented by Dr. Krivsky for Union Carbide. He is president and founder of The Keyson Co., Inc. of Bedford, N.H. . . . **Bernard Widrow**, Stanford professor of electrical engineering, was awarded the 1986 Alexander Graham Bell Medal and $10,000 for "exceptional contributions to the advancement of telecommunications." The award stems from the current use of adaptive processors or "learning machines," which he began developing at Stanford in 1959, and was awarded by the Institute of Electrical and Electronic Engineers and sponsored by the American Telephone and Telegraph Co.—**Gregor J. Gentleman**, Secretary, 600 Holcomb, Suite 1, Des Moines, IA 50313

52

In the last exciting installment of our class notes, I mentioned **Edward Remmers**' distress at the statement from the Student Financial Aid Office that there were no descendents of class members who were undergraduates at M.I.T. Ed was under the impression that his daughter Barbara was a junior in Course 18, an impression he probably formed while writing checks for tuition payments. I threw out the guess that the student aid people only meant that no class descedents required aid. Like so many of my opinions, this was plausible, and wrong. The student aid office explained that the information about Barbara's relationship to a member of our class simply had not made its way from the Admissions Office to the Student Financial Aid Office. One moral of all this is to remind your children, or eventually grandchildren, if they are applying for aid as undergraduates at M.I.T., to mention their relation to our class. Another moral, of course, is to send contributions to better support our scholarship fund.

Theodore Parsons writes that he is a senior financial analyst with Merrill Lynch in Miami. . . . **Bruce Curry**, another Course 13 graduate, joined Peat Marwick last fall as director in charge, Computer Resource Department. A Course 13 man who has stayed with the field, **John Paulling**, professor of naval architecture at Berkeley, was elected to the National Academy of Engineering last winter.

Harold Hart says that he was recently promoted to planning analyst I at Southern Company Services, Inc., in Atlanta. He is employed in data processing. . . . **Sandy Isaacs** is also at work moving bits around. He is now at Oxfam America, headquartered in Boston, where he is networking microcomputers to one another and to service bureau mainframes. What did we do before we had computers to play with? . . . **Alan Geisler** writes that he is recovering from a hip replacement but is otherwise fine. We certainly wish him a good recovery.

I have been saddened by receiving notices of the deaths of two classmates. **Matthias F. Comerford**, who was R&D manager of Hollis Engineering of Nashua, N.H., died November 7, 1985. He received an S.B. in physics and a S.M. and Sc.D. in metallurgy from M.I.T. A resident of Newton Highlands, Mass., he is survived by his wife Paula and five children. . . . **John C. Mott-Smith** died June 15, 1985. I had gotten to know him quite well as an undergraduate in Course 8, and even better when we roomed together for one year in the Graduate House after the air force had sent him, a newly-commissioned second lieutenant, back to M.I.T. for a master's degree. After leaving M.I.T., he worked at Air Force Cambridge and its successor agencies, as far as I know, for the rest of his life. Since he remains in my memory a young man in his early twenties, the news of his death was especially shocking.—**Richard F. Lacey**, Secretary, 2340 Cowper St., Palo Alto, CA 94301

53

This has been a relatively good month for getting inputs from and about our classmates. Unfortunately, we missed a few months during this past year because of a dearth of material, but if you continue to let me know how you're doing, I'd be happy to let the rest of our classmates know.

First of all, **Howard S. Stern**, whom we last saw at our 30th reunion, informs us that he has been president of E-Z-EM, Inc., for the last two years. The company is publicly held, and Howie is working very hard to keep the company going and growing. Howie's two children are now 16 and 18; he looks forward to seeing us all at the next reunion so he can tell us more about them. . . . Next we hear some enviable news from **William M. Gardner, Jr.**, who took advantage of Dupont's early retirement opportunity program and retired over a year ago. His retirement concluded an enjoyable 31-year career that included management activites at Dupont. At the time he wrote us, around the start of this year, he said he was doing absolutely nothing productive and having difficulty finding time to do that. Bill, hope you continue to enjoy your retirement, and many of us will look forward to being in your position over the next few years. . . . Our third correspondent, **Malcolm J. Blair**, tells us that he was recently named managing architect of the Suffern, N.Y., office of Chase Architectural Associates. It appears that he is very pleased with his new position, particularly because he now doesn't have to move from the Syracuse area. Lots of luck in your new position, Mal.

Although I'm sure almost everyone has heard of the Nobel Foundation and the prizes that they award every year, perhaps not too many of us have heard of the Inamori Foundation. They are about to award their first Kyoto Prizes, in fields that are not covered by the Nobel Prizes. One of the first winners of this prize will be our classmate **Rudolf Emil Kalman**, who is a professor at both the University of Florida and the Swiss Federal Institute of Technology in Zurich. He will receive the first Kyoto prize in advanced technology for his work in control engineering and system theory. The awards will be given out at the International Conference Hall in Kyoto, Japan, on November 10, for any of you who would like to be there to see him receive the prize. Professor Kalman has had a distinguished career in academia after receiving his bachelers and masters degrees at M.I.T. and his doctorate from Columbia University in 1957. We are very happy and proud to hear of his award.

On a sadder note, I have to inform you of the passing on January 9 of our friend and classsmate, **Norman R. Gardner**. We are very distressed to hear of this and our sympathy goes out to his wife, Elaine.—**Wolf Haberman**, Secretary, 41 Crestwood Dr., Framingham, MA 01701; **Joseph M. Cahn**, Assistant Secretary, 289 Bronwood Ave., Los Angeles, CA 90049

54

Harvey Steinberg is co-chairman of a drive to create an independent "Fund for the Arnold Arboretum," in the Jamaica Plain area of Boston. The endowment fund is the work of the Boston Natural Areas Fund, Inc. (BNAF). Such a fund would support the physical care of the arboretum land and plantings, thereby freeing the arboretum's academic income for teaching and research. The BNAF reports that the 100-year-old Arnold Arboretum is the only facility in the world that is both a public park and an area for scientific botanical research.

Paul Gray appears in the news with some regularity and, as we have noted in the past, it is im-

possible to keep up with all of his activities. Last spring, however, he appointed a board that certainly merits mention here. He appointed 12 outstanding people to a Lincoln Laboratory Advisory Board, which will assist Provost John Deutch by providing advice on research programs and future directions of the laboratory. The appointments included two alumni, Solomon Buchsbaum, '57, and Burton Richter, '52.

It is with great regret that we report the death of **George Inada** in April 1985. George, who graduated in electrical engineering, lived in Bethesda, Md. We extend our sincere sympathy to his wife and his daughter.—**Edwin G. Eigel, Jr.**, Secretary, 33 Pepperbush Ln., Fairfield, CT 06430; **Joseph P. Blake, Jr.**, Assistant Secretary, 74 Lawrence Rd., Medford, MA 02155

55

The news from the West is so sparse that I had to raid **Bob Greene**'s territory for something to report. Nancy and I had a nice visit from Meg and **Marty Gilvar**. They have been married for 30 years and live in Oakham, Mass. Marty is director of technology for Morgan Construction Co. He has been with them for 27 years. Meg is teaching fouth grade students, and they have three children—John (27), Jenny (25,) and Teddy (20)—plus two grandchildren. Marty collects old cars, and last count had him up to six antique cars plus a few normal ones. Do they run? Ask Marty.

I received an informative letter from **Don Steig**. Let me paraphrase most of it. "After 29 years of working for other people, I left the position of vice-president of information services for Margrace Corp., a direct mail firm, early last year to go into business for myself. I formed a consulting company, Practical Computer Solutions, Short Hills, N.J., specializing in providing computer related assistance to health care, direct mail, and consumer and industrial product organizations. Business has been good. I don't quite match your 30 years of marriage but will reach 27 this year. My wife, Janet, is an insurance agent/financial planner. Daughter Jenifer is a Cornell graduate working in facilities planning in Washington, D.C. Older son Adam is a Cornell sophomore interested in becoming an attorney, and younger son Jordan is awaiting college acceptance notices. My athletic activities include running, squash, tennis, skiing (downhill and cross-country), swimming, and hiking. I continue to assist in M.I.T. affairs, currently as regional chairman for Northern New Jersey for the Education Council."

John Gahran passes along the information that he is now a member of the board of directors of Packaging Accesssories Co. in Lionville, Pa., and Compositech, Ltd., in Westbury, N.Y., in addition to being president of Gahran and Co., a management consulting firm founded in 1976.

That's it for this month. Come on, West Coast, let's get some information to me so we can show the East the excitement and diversity of our activities.—**Robert P. Greene**, Eastern Co-Secretary, 37 Great Rock Rd., Sherborn, MA 01770; **DuWayne J. Peterson, Jr.**, Western Co-Secretary, 1841 Warwick Rd., San Marino, CA 91108

56

Emmanuel P. Papadakis has been appointed supervisor of Quality Systems Concept in the Manufacturing Development Center of Ford Motor Co., Redford, Mich.

Robert Perez-Amador is still with Exxon Engineering, based at Florham Park, N.J., but has been on assignments in Japan and Italy. As you read this, you will remember being with him at our 30th reunion.

Charles A. Ber professor and chairman of the Mechanical Engineering Department of Northeastern University has been made a fellow of the American Society of Mechanical Engineers. This is the highest distinction conferred upon A.S.M.E. members and recognizes significant contributions to the engineering field. Charles has worked in industry and government. His research has focused on how solids and composite materials fracture. In the early 1970s he was chief engineer of the Federal Power Commission.

And last but not least, **Richard Jacobs II** will live the life of a professional ballplayer for a week at a Randy Hundley/Chicago Cub Adult Baseball Fantasy Camp. Richard will receive daily instruction in hitting, baserunning, fielding, etc. from former greats. He and 40 other ex-jocks, sports fans and weekend athletes share a common denominator: a desire to return to their youth, escape responsibilities and live life as a Chicago Cub. I'm sure many of us can identify with the wish to go back, at least for a week. Sounds like fun.

I join Bob in bidding you farewell in this, my last column as Co-Secretary. It has been interesting, and I must thank Bob for coming to my rescue a couple of times and for being a very nice Co-Secretary to work with.—**Robert Kaiser**, Eastern Co-Secretary, 12 Glengarry, Winchester, MA 01890, (617) 729-5345; **Caroline D. Chihoski**, Western Co-Secretary, 2116 W. Davies Ave., Littleton, CO 80120, (303) 794-5818

57

Marilyn Peterson writes to report the death of her brother-in-law, **Norman Lee Peterson** on April 17, at his home in Urbana, Ill. He was chairman of the Department of Metallurgy and Mining Engineering at the University of Illinois, a position he had held for only a short time. Prior to accepting the Illinois appointment, he had worked at the Argonne National Laboratory for over 25 years, beginning there while still a graduate student in the late 1950s and resigning in the fall of 1985 from the post of group leader of basic ceramics. From 1968 to 1977, he served as associate director of the Materials Science Division and in this capacity led one of the largest materials science programs in the Department of Energy.

Dr. Peterson enjoyed an international reputation for his research on diffusion mechanisms in crystalline and amorphous solids and on the structure and properties of grain boundaries in solids. In 1973 he was awarded a Senior Humboldt Fellowship and over the past dozen years had been elected to fellowship by the American Society for Metals, the American Physical Society, and the American Ceramic Society.

At M.I.T. Dr. Peterson was a member of the Theta Delta Chi fraternity and served as treasurer of the chapter during his senior year. He participated in several undergraduate activities and particularly enjoyed his four-year association with Tech Show, of which he became the general manager for the 1957 production.

Dr. Peterson remained at M.I.T. for his graduate work and received his M.S. in 1959 and Sc.D. in 1961. He is survived by his wife, Mary Lee, to whom he was married in 1963. Other survivors include his brother Franklin P. Peterson, a member of the mathematics faculty at M.I.T., and a cousin Byron J. Peterson, '63.—*ed.*(**Vivian G. Warren**, Secretary, 156 Northrop Rd., Woodbridge, CT 06525)

58

We have lots of interesting news from several of our far-flung foreign-based classmates. From Hawaii we received an aloha from **Bernie Schneiderman** telling us that "after nine years as manager of Hawaiian operations for LTV Corp., I have left to help build up a branch of the Command and Control Department of the Naval Ocean Systems Center. This department will provide analytical and computer systems engineering support to military commands in the Pearl Harbor area. Sheila and I have three children: Sandy, a recent graduate of the University of Hawaii in economics; Barry, a third-year engineering student at Harvey Mudd College; and Maria, a third-year high school student. Old buddies are invited to give us a holler when they visit the islands."

With everyone vacationing in Hawaii or Florida these days instead of Europe, I have the feeling that Bernie is likely to get more than a few calls. . . . From **Mike Balderston**, the class's very own "Wonder Down Under," we heard that "after many years, off and on, with Telecom Australia, I have left to join a new company, Equatorial Satellite Systems, as network services manager. We are licensed by, and partially owned by, Equatorical Communications in Mountain View, Calif. We are one of many new ventures resulting from the launch of Aussat last year, and the U.S., U.K. and Japanese examples of telecommunications deregulation. Unfortunately, we have no East Coast offices yet, so there is not much chance of me returning to M.I.T. for a visit for at least a while."

And from Norway, **Tom McClimans** sent a letter bringing us up to date on his activities. "In 1981, I received the Norwegian doctor of technology degree for six published works on the hydrography, dynamics and energetics of fjords. Then, in 1984, I received a prize from the Foundation of Industrial and Technical Research in Trondheim for my work on mesoscale eddies in the Norwegian coastal current. Last year, I was promoted to head of research at the Norwegian Hydrotechnical Laboratory and appointed adjunct professor of applied oceanography at the Norwegian Institute of Technology. This year I have been very busy indeed and had little chance to do any skiing. Else and I have three children—Else (17), Kari (16), and Ole Thomas (11). For those of you traveling to Trondheim, we live within walking distance of the city center and are the only McClimans in the telephone directory. Last summer we had the pleasure of hosting Sheila Widnall of the M.I.T. faculty during her visit here."

As this month's armchair cruise of international ports draws to a close, we say, "G'day, mate!"—**Michael E. Brose**, Secretary, 534 East Broadway, South Boston, MA 02127

59

Right to the news. The first item comes straight from the National Academy of Engineering. Two classmates, **Bill Poduska** and **Daniel I.C. Wang**, were elected to this distinguished body early in the year. Congratulations to both of you from all of us. Wang, who is a professor of biochemical engineering at the Institute, was recognized for his basic contributions to the field of biotechnology. Bill was cited for technical and entrepreneurial leadership in computing, including the development of Prime, Inc. In a recent *Business Week* article, Bill was referred to as one of the most interesting " 'graybeard entrepreneurs,' industry veterans whose depth of experience makes them good risks" for investors. As some of you may know, Bill has just launched a new company, Stellar Computer, Inc., to develop "superworkstations" for the computer-aided design market. But how does that term "graybeard" make the rest of us feel?

I had a nice chat with **Allen Bufferd** the other day. Allen was recently promoted to the position of deputy treasurer at M.I.T. He is now the director of investments there managing the Institute's not inconsiderable portfolio including, I presume, the resources behind the Class of 1959 Scholarship Fund. Allen's daughter, Lauren, is living in Chicago, and son, Steve, a recent Lehigh grad, is spending the year in China. By the time you read this Allen and Rhea will have visited Steve, enjoyed a fine reunion and tour, and I suspect, become entirely fluent in the local dialect. Allen passed on information about some of our classmates also. **Bob Buh** is now managing director of Bear Stearns' office in San Francisco. But he's active in Cambridge too, serving on M.I.T.'s Corporation Development Committee and, most

recently, chairing the Nominating Committee of the Alumni Association. Also, **Larry Bishoff** has left M.I.T., the employer, to become administrative director of the Harvard Community Health Plan, a Boston area H.M.O.—the largest in Massachusetts. Finally, Allen reports that **Kent Kresa** has just been appointed senior vice-president at Northrup Corp. in Los Angeles.

More good news. Several '59ers have provided a bit of news about themselves this month: **Tom Crystal** reports that he has just been elected president of the IEEE Acoustics, Speech and Signal Processing Society for 1986-87. . . . **Cliff Benzel**: "I have been appointed vice-president for relief and large scale development at World Vision International. Much of the last 18 months I have been in Africa, particularly Ethiopia. Millions of lives have been saved because of the giving of Americans. The big job finding long-term solutions still remains." . . . **Gerald Schroeder**: "Barbara and I have five kids, 2 to 10 years old. In spite of the bedlam which comes along with this crowd, I am getting set for my sixth trip to China (People's Republic) where I advise on integrated crop-land animal-fish farming and on the establishment of joint Chinese-foreign farming projects. I am convinced that an M.I.T. education prepares one for almost any professional problem." . . . **Frederic Y.M. Wan**: "In 1983 I left the University of British Columbia, where I had been professor of mathematics and the director of the Institute of Applied Mathematics and Statistics since 1974, to become professor of Applied Mathematics and Mathematics at the University of Washington. Appointed chairman of the new Department of Applied Mathematics at its inception in July 1985."

A tragic accident in April took one of our classmates. According to the *Boston Globe*, **Adrian R. Reti** died with three others in the crash of a helicopter in Holliston, Mass. Adrian was a senior vice-president and vice-president of science and technology at Millipore Corp., Bedford. He had been with the firm since 1971. In addition to his Millipore titles, he was also president of Millicorp, a subsidiary of Millipore. Adrian had earned his bachelor's, master's, and doctor of science degrees in chemical engineering at M.I.T. Our sympathy to his wife Marie and their three children.

Well, that's all for this edition. Trust that you are enjoying a pleasant and, at least, somewhat relaxing summer.—**Ron Stone**, Secretary, 116 Highgate Place, Ithaca, NY 14850, (607) 257-2249

63

Thanks to all you fine folks who have kept sending newsy cards and letters. Here's a pungent observation: "How do you know you're getting older? When you no longer fear the orthodontist, but the periodontist looks like the big bad wolf." That comes from Georgie Hallock, wife of **Jim Hallock**. Georgie wrote a nice letter about other class members, in which she reports: **Roger Pyle**, his wife Tiza, and their two children—Bob and Kathy—visited the Hallocks recently. Bob has been accepted to Tech for this Fall. Also visiting the Hallocks were **Don Knutson** and Andrea (Allen) Knutson, '65, and children. Allen, the older child, will soon be off to college, while Miranda is about a year old. Don works for the CBS TV network, and Andrea works with computer application programs, I believe for Boeing.

Paul Berger writes that he has spent the past ten years at Lincoln Labs, assigned to New Mexico, California and Hawaii. He and wife Eleanor and Lorie (19), Rosemary (16), Maria (12), and Natalie (9) live in Lexington, Mass. Paul now leads a group developing adaptive optics for high-power lasers. The Bergers celebrated the year of their 20th wedding anniversary by sending Lorie to Dartmouth. . . . Ah, Paris! That's where **Tom Lewis** and his wife Margaret went last summer, with children Ian and Tommy. Margaret brushed up her French, then the family went to Scotland to visit her family. Ian and Tom also visited Disneyland in the fall. Tom is an independent computer consultant, currently under contract to the Bank of New York. . . . Greetings to all his friends from **Marco Falcon**, who is Director of the Instituto de Mecanica de Fluidos at the Central University in Caracas, Venezuela. Marco hopes (and wishes we would all hope) for return to oil at (in 1973 dollars) $50 a barrel. I am afraid, Marco, that with all due respect to our shared experiences at Tech, classmates living in most of the United States—outside Texas and Oklahoma—may not concur. Thus doth economics make rivals of us all. . . . **Bob Bolus** was at the C. S. Draper Lab for seven years working on inertial guidance, then two years on ocean measurement at the Virginia Institute of Marine Science. Now he is assistant professor at Norwich University in Vermont, teaching communications, electronics, computer programming, etc. He also has an interest in digital signal and image processing.

There is also some sad news. The Alumni Association reports to me the uncorroborated news of the passing of **William Lord**, who had been living in Los Angeles. If anyone has information about when and where this occurred, and what family he left, I will pass it on through this column.

Let me end on a happier note, one that makes me proud. My son Gary, who is finishing his sophomore year in high school, announced some months ago that he had seen enough high school, and was ready for college. He campaigned for and obtained an offer of admission from Hampshire College, a liberal arts school in Amherst, Mass. Now if I can only figure out how to pay for it.—**Phil Marcus**, Secretary, 2617 Guilford Ave., Baltimore, MD 21218, (301) 889-3890

64

As I'm writing, it's mid-Spring and the annual tourist invasion of Washington, D.C., is well underway. The traffic gets very heavy at times, especially around the monuments and the Smithsonian, but I guess it's a small price to pay for having our local culture available at low (taxpayer-subsidized) prices. Louis and I encourage class of '64 people to come play tourist and give us a call.

The news envelope is in good shape for this issue. As always, first priority goes to classmates who actually send a real, honest-to-goodness letter. **Lita (Donnelly) Nelsen** writes that she has joined the M.I.T. Technology Licensing Office after 20 years in industry. Lita is having "fun applying industrial-style marketing techniques to M.I.T.'s fascinating melange of inventions." Her other, along-the-way milestones include returning to M.I.T. in 1978 as a Sloan Fellow, marrying Don Nelsen, '61, 18 years ago, two kids—Katrina (16) who's "dreaming of M.I.T. or Harvard" and Dan (13), and serving as president of the Association of M.I.T. Alumnae. Lita sends best regards to all. . . . **Alton Otis** writes that his consulting business has continued at a hectic pace. It is based in the Bay area and ranges from telephone marketing devices and disk drive testers to talking teddy bears and robotic cats. Alton was in Boston several years ago and noted that although the new 10-250 was a marvelous surprise, the rest of the Institute could use a few coats of paint. It sounds to me like Alton has just volunteered to take on some Alumni Fund responsibility.

Jay Tenenbaum continues as director of the A.I. Laboratory at Schlumberger Palo Alto Research. He is also a consulting professor in the Computer Sciences Department at Stanford, concentrating on engineering applications of artificial intelligence. (A lot of people seem to be taking A.I. very seriously; there were more than a few nasty looks when, at a recent staff meeting, I whimsically proposed creation of a Center for Artificial Excellence.) . . . **Bill Nelson** is the director of engineering for Ortho Pharmaceutical Corp. in Raritan, N.J. In November 1985, he was elected to the Township Committee of East Amwell Township, N.J. . . . **Cary Mock** is currently the director of acquisitions for Westinghouse Electric. He is married with three children.

David Hoover is finishing up a stint as Interim Dean of the Barney School of Business and Public Administration at the University of Hartford. This fall, he will be on sabbatical and finishing a "long overdue dissertation." He has been bouncing back and forth between Connecticut and Boston where his wife is a professor. . . . More academic news. **Bob Weinberg** is still a member of the Biology Department at M.I.T. He now also has a joint appointment as a member of the Whitehead Institute for Biomedical Research. . . . Also in Cambridge, **Duncan Miller** is currently managing the Simulation Department at B.B.N. Laboratories, Inc. His primary project is a distributed, computer-based network for real-time, large-scale battlefield simulation. Perhaps Duke's experiences as a Baker House Judcomm member could provide some useful background.

Dave Holden edited the recent Disney film "The Journey of Natty Gann." His other interests include Highfield Ranch, an exotic game ranch near Santa Barbara. Over the last year, eland, gemsbok and zebra were born at the ranch. . . . **Frank Cornelius** had a busy 1985. He produced a package of legal software for estate planning with closely held businesses. Frank also had his treatise on trade secrets and convenants not-to-compete published in *The University of Detroit Law Review*.

Please drop a line with your personal and professional news.—**Joe Kasper**, Secretary, 3502 Idaho Ave., N.W., Washington, DC 20016

65

Bernard Goodman writes that he is living in Cambridge with his wife and three sons, and working as a system programmer at Draper Lab. . . . **Bruce Fauman** sent a note that he is living in Vancouver, B.C., and is a university executive and professor at the University of British Columbia. Bruce points out that he was recently an undefeated champion on the TV game show "Jeopardy" and runner-up in its "Tournament of Champions"—not bad for a technically educated type. . . . A newspaper clipping from Portland, Maine, notes that **John Berry** was a candidate for the local Board of Education last fall.

Harvey Kaye has published a book, *Inside the Technical Consulting Business: Launching and Building Your Independent Practice*. Harvey developed the book in part on the basis of his experience as an independent consultant in Amherst, Mass. . . . **Ed Strauss** has been named to the executive committee of the Pittsburgh law firm of Berkman Ruslander Pohl Lieber and Engel.

Finally, I am sad to report a note from **Jim Hartman**'s brother that Jim died last March 25 after a 15 month battle with leukemia.—**Steve Lipner**, Secretary, 6 Midland Rd., Wellesley, MA 02181

67

John Rudy and I talk from time to time regarding the plans for our 20th reunion, which will take place Friday, June 5, through Sunday, June 7, 1987. You will, of course, receive another letter from our reunion committee when the specific events and locations have been determined. In the meantime, John requests that you send in the reunion questionnaire if you have not already done so. John estimates that of the 135 classmates responding to date, approximately 85 will attend. The reunion will be fun, so do plan to attend.

After two years at GTE, **David McMillan** has returned to MITRE Corp. as a department head overseeing projects involving missile and space defense. The McMillans still live in Winchester and hope to see some old friends during our 20th

Filmmaker Andrew Silver (class of '64) confers with Karlene Crockett and John Walcutt about a scene in "RETURN." Silver holds two business degrees from M.I.T. and a doctorate from Harvard Business School.

A SUSPENSE TALE WITH A FINE TOUCH OF CLASS.

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"Notable for its lack of sexual and violent exploitation. Karlene Crockett is as talented as she is beautiful."
-Michael Blowen, The Boston Globe

"I wanted to make a film based on love instead of fear. I wanted special emotions instead of special effects."
-Andrew Silver

" 'RETURN' is a gem! THE ONE for those in search of a good movie. A good story that has been tautly directed and acted."
-Virginia Lucier, Middlesex News

"A happy cinematic surprise... spectacular performances. Cinematographer Janos Zsombolyai is brilliant!"
-Norma McLain Stoop, Manhattan Arts

"One of the most beautifully filmed independent movies I have seen. In John Walcutt and Katherine Crockett, Silver has found two unusually gifted performers."
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SEND CHECK TO: ANDREW SILVER, P.O. BOX 1414, BOSTON, MA 02117

Please send me a video cassette of "RETURN" @ $37.95 ($34.95 plus $3.00 shipping and handling). Mass. residents add 5% sales tax. (VHS only)

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reunion. . . . **John Halberstadt** is still with Du Pont and since 1984 has been the project manager for a new caustic-chlorine plant to be constructed at Niagara Falls, N.Y. John Jr. is a sophomore in chemical engineering at Clarkson University (which raises a sobering thought: John Jr. is now older than his father and I were when we first met as freshmen at M.I.T.) John Jr.'s younger sister and brother are in high school and keep their parents more than busy. I hope John and Penny make it to our 20th. . . . **Don Berliner** is in Pennsylvania with Merck, Sharp & Dolme, a pharmaceutical firm, and is heavily involved with microcomputer systems. Don has found time to continue free-lance writing, his most recent work being to revise Que Corp.'s *Using Symphony* book to conform to the latest version of the software.

Ray Ferrara is working for Digital Equipment Corp. in corporate MIS—he's helping to computerize a computer company! He and Mary have their first child, Christopher, a fun-loving toddler who is rapidly approaching age two. . . . **Carl Kalinowski** and On-The-Go Computer, a microcomputer CAD specialty business, have completed their third year. On-The-Go Computer is a systems integrator for popular software packages, such as Autocad and Anvil, with a demonstration center in Woodbridge, N.J. Carl lives in a townhouse in Somerset, N.J., and would welcome calls from local alumni who are interested in consulting for clients of On-The-Go Computer.

Bob Domnitz asks how our class would feel about boycotting the Alumni Fund to protest M.I.T.'s involvement with SDI. . . . **John Hamilton** is at Sandia National Laboratory in Livermore, Calif., doing research using laser Raman scattering to monitor high temperature interface reactions in real time. He remarried last August and spent his honeymoon in Zimbabwe.—**Jim Swanson**, Secretary, 878 Hoffman Terr., Los Altos, CA 94022

69

Summer has come to Washington and it's still spring! To give you non-Washingtonians a flavor for the environs: An ad seen prominently on Metro walls: "The most important bank in the world's most important city thinks you're important too." People have been known to take important lessons here! And now we'll see how some of D.C.'s international visitors feel about all this. **David Kjang**, for example. David joined the First Interstate Bank in September 1985 and is now managing its banking business with China. He's stationed in Hong Kong. David, is your bank and your city important or more so than THE bank? Tune in next notes for answer.

On the other coast we peer down at **Alan Davis** as we fly into Palo Alto. He writes that "life continues at Schlumberger Palo Alto Research where I lead a group of ten people developing a highly parallel symbolics processor. On May 10 (it must have happened already), I look forward to seeing a number of classmates at **Rolf Brauchler**'s wedding—yes folks, the confirmed bachelor has finally met his match." Well, at least his mate. . . . **David Hill** says that he recently became vice-president and general manager of Metglas Products, a new venture company pioneering amorphous metal technology. . . . Jumping coasts once again, we hear in a news release about **Roger Lewis**, who has been advanced to the prestigious College of Fellows of the American Institute of Architects in recognition of his achievements in education, literature and design. Lewis is a practicing architect, author and columnist, and faculty member at the University of Maryland School of Architecture. He writes "Shaping the City," a weekly column in the *Washington Post* focusing on architecture and urban design. M.I.T. Press published his book *Architect? A Candid Guide to the Profession* last year. The book is being adopted as a basic textbook by architectural schools throughout the United States.

I highly recommend to you an article by **David Burmaster** in the January/February issue of *Environment*, "Groundwater: Saving the Unseen Resource." Don't ever take your well water for granted! David works in Cambridge, Mass., as a consultant on risk assessment, exposure assessment, hazardous waste management, and ground water contamination.

I've got to get back to writing my book—title to be announced. I've promised my publisher that each and every one of you will buy a copy, and that's a promise! Speaking of Washington, didn't "Jimmy" say that? Or was it, "And you can count on it?" Who cares?—**Eugene Mallove**, 11902 Paradise Ln., Herndon, VA 22071

70

Jeffrey Sagarin has developed computer rankings for college football and college basketball that are published every Tuesday in *USA Today*. . . . **Edward De Vos** has two daughters, Erica and Sarah. He has received a doctorate from Harvard in human development, specializing in research, measurement and evaluation. He was director of research and evaluation for the Massachusetts Executive Office of Human Services but currently is directing a research study on sexual victimization of children at Children's Hospital. . . . **Lance Tibbetts** is a pathologist and specializes in cancer research at Brown University. He has two children, Amy and Andrew. . . . **Steven Oreck** is in private practice in New Jersey, specializing in hand surgery and microsurgery. He recently presented a paper at the annual meeting of the American Society for Surgery of the Hand on the mechanics of wrist injuries. . . . **Arthur Perkins, Jr.**, has moved to South Bend, Ind., to head the purchasing department of Uniroyal Plastics Co., Inc., and he and his spouse Gerri are expecting their first child. . . . **Paul Burstein** has recently become director of Applied Physics at AS&E. His recent mid-life crisis resulted in his buying a Saab. . . . **Paul Guanaldi** is a partner at Vesper Properties, at One Post Office Square, where he develops real estate along the eastern seaboard. He is currently involved in the construction of buildings totaling 1,000,000 square feet. He is also a principal in Valiner, which is a computer company specializing in implementing local area networks and engineering support not available at typical computer stores. . . . **William Meyer** discovered new forms of logic in law school after having mastered computer programming. He has passed the Massachusetts Bar and is now a patent attorney.

It is with deep sadness that we report the untimely death of **Michael Pagano.** He was most recently the director of product planning for Interleaf, a Cambridge-based maker of computer aided publishing products. His parents have organized a fund in his name to recognize achievement in science and math by students in high school. Contributions should be made to the Michael A. Pagano Scholarship Fund, and sent to: Judy Chapman, Treasurer; Wesfield Academy & Central School; Westfield, NY 14787.—**Robert O. Vegeler**, Secretary, Beers, Mallers, Backs, Salin & Larmore, 2200 Ft. Wayne National Bank Bldg., Fort Wayne, IN 46802

71

This issue's class notes are being typed in April. Hopefully we will have had a successful class reunion. I hope to publish some pictures and news about the reunion in November or December. . . . **Leonard H. Towrey** writes, "I have been working since July 1985 with **Richard Stallman** on Project GNU. Our goal is to develop and place in the public domain a complete UNIX-compatible development system. We expect a first release by the end of this year." . . **Barry I. Levine** writes: "I am now an acupuncturist practicing in Roslindale, having completed two years of study at the New England School of Acupuncture. Am presently studying Chinese, also. . . . **Thomas R. Smith** and his wife Margo are expecting their third child in September. He started a new job as training manager for Cognition, Inc. Lots of changes. . . . **Marc Covitt** has moved from supporting computer systems for Hewlett-Packard to selling them in San Diego. Right now he is trying to get back in shape after tearing his knee playing basketball.—**R. Hal Moorman**, P.O. Box 1808, Brenham, TX 77833

72

Peter Terwilliger was married in July 1985 to Kathi Burke of Bangor, Maine. They have "finished (almost)" building a house in Waltham. . . . **Harlan Ives** lives in San Francisco with his wife Shelley and daughter Rebecca (2). He's assistant professor of medicine at U.C.S.F. doing research on H+ transport across biological membranes. . . . **Andrew Edward Moysenko** is manager of Gallium Arsenide materials at Sanders Associates Microelectronics Center in Nashua, N.H., and secretary of the Northern New England chapter of the Institute of Environmental Sciences. . . . **Alfred Morgan** is opening a veterinary clinic with his wife, Susan Dolowitz Morgan (Wellesley '72), in northwest Portland. . . . **Keven Trangle** is director of the Immediate Care and Occupational Medicine Divisions for a 100-physician multispecialty group in Cleveland. He is also "investing time and money in starting new medical/technology ventures." . . . **Bonny Kellermann** and her team won bronze medals in precision skating in the national championships.

Alfedo Sadun writes, "It will probably come as a surprise to many of my classmates that I have moved my family—Debra, Rebecca (5), and Elvio (2)—to Los Angeles. I left behind the overrated position of assistant professor at Harvard Medical School and, more important, a view of the Charles, to set up my lab in Southern California. My joint appointment in Opthalmology and Neurosurgery at U.S.C. and major collaborations in neuroscience and psychophysics at Caltech and J.P.L. keep me stretched transparently thin. Although we all miss Boston and New England friends, the present climate of 'can do' scientists and the meteorological climate here combine to make our lives very pleasant. Write!" (Your class secretaries heartily concur with the final injunction!)

Some, we hope all, of you may remember that a while back the class solicited money for a class of '72 fund to be used to aid UROP projects. The fund has been a glowing success and has helped fund the following projects: Deren Hansen's work on infrastructure solutions to problems with the Boston sewer system; Pauline Fischer's work on preserved learning capacities in patients with severe memory disorders; Sherry Lee's development of a pilot test of a motor assessment procedure for non-vocal patients; Eric Raiten's analysis of U.S. vulnerability to space weapons and methods of verifying a test ban on antisatellite weaponry; Sharon Crawford's study of energy efficient building design; Larry Shapiro's work on controlling acid rain; Dale Rothman's research on air pollution; Andrew Plump's work as an intern with state representative Peter Vellucci, which included being the author of a new Massachusetts law combatting arson. That's all the good news. The bad news is that the class of '72 fund is out of money, so an extra contribution to the Alumni Fund designated for the class of '72 UROP fund would be definitely in order.

Finally, we had a meeting at **Bonny Kellermann**'s to begin to discuss next years reunion (how can 15 years pass so fast?) and an associated class gift to endow the UROP work we have been supporting. Volunteers for the reunion should contact President **Kellermann** at 1070 Beacon St., Apt. 5B, Brookline, MA 02146, 232-7140 (home), 253-3354 (office). Volunteers to work on the class gift should contact **Linda Mayeda**, 929 Mass. Ave., Cambridge, MA 02139, 491-7063 (home),

492-5500 (office).—**Dick Fletcher**, Northern Secretary, 135 West St., Braintree, MA 02184

73

Word comes from **David Dahlbacka**, who received a master's degree in Computer Science from the University of Illinois last August. He is now working as a software engineer in Boston. . . . **Karl Gallegos**, an M.D. working in the field of substance abuse, is in research and clinical practice in the Atlanta area.

A welcome letter came from **John Wall**, who sent along an update to some information in the previous issue. John recently left Chevron Research Co., moving to Cummins Engine Co. as chief engineer for heavy duty products. He will be leading the development and design team for new engine types. A job change meant leaving San Francisco for sunny Columbus, Ind., but returning to the "heartland of America" was a pleasure for John, who writes that since his wife Nancy can "retire,"she has no complaints. . . . **Tom Ellis** writes, "I dropped into the alumni center after a business trip. I'm still at Hughes Aircraft Co., building satellites. We were trying to buy parts for Milstar from Route 128. I found time to buy a T-shirt for my 3-year-old son Matthew in the Coop. This was the first time in eight years I've been back; the place hasn't changed much."

My new quartet, the Portsiders (we're all left-handed by coincidence) competes in a regional contest in a few weeks. More on that next time out. More importantly, I have been named manager of information systems for Allen Corp., Alexandria, Va., a division of Singer. My first duty is setting the new VAX system up. Write!—**Robert M.O. Sutton, Sr.**, Secretary, 1302 Churchill Ct., Marshall, VA 22115

74

Fellow classmates, do you realize that the entering class of freshmen in September will be the Class of '90! One other fun fact: 36 percent of those accepted were women. That doesn't mean that that all will elect to come to the 'Tute, but it is about the percentage of women who *should* be accepted. Tuition for the Class of '90 is $11,800.

Your faithful scribe had a good time at the May Telethon. Got to talk to a few classmates. . . . **John S. Looper** (as opposed to **John F. Cooper**) is a psychiatric resident at Beth Israel Hospital in Boston. He says, "I'm in my first year of residency, working 75 hours a week, but it's still better than being an intern." . . . **Ron Frere** has come "out from behind the corporate facade back into the real world," taking over the Texon, Inc. division of Emhart Industries. He's putting the $200 million footwear materials operation back on its feet (if you'll excuse the pun, aughh!) . . . **Matthew Kaufmann** sounded happy as can be: "I live in Austin, Tex., and it's great!" Matt's working for Burroughs at their Austin research center, applying concurrency to applicative programming languages.

David Tirrell is an associate professor of polymer science at the University of Massachusetts. His studies involve developing ways for medicines to navigate through the bloodstream in microscopic capsules where they can be delivered directly to the site of an infection. . . . Dr. **Robert S. Lee** has been elected to fellowship in the American College of Cardiology. . . . "Consulting in AI, as well as other responsibilities, keep me very busy, but never bored," writes **Amos Oshrin**. After receiving his master's degree at the Sloan School in 1983, Amos joined Intellicorp, producers of artificial intelligence software. . . . Also busy and working hard is **Elizabeth Newton**, finishing her master's degree in operations research and statistics at M.I.T.

Two whimsical notes end the column this month. From Dr. **Stephen Blythe**: "In family practice in Lubec, Maine, doing old-time general practice in a very remote but beautiful seacoast village. Yes, I make house calls!" . . . **Alan Harper Jones** writes: "I am now president of an engineering consulting company called Glenlogic, Inc., which is inspired by good scotch."

Thanks to all who wrote this time. Have a hummer of a summer.—Co-secretaries: **Lionel Goulet**, 20 Melville Ave., Dorchester, MA 02124; Dr. **Richard Sternberg**, Box 3209, Alexandria, VA 22302

78

It is my saddest duty as class secretary to report to you the deaths of two of our classmates. According to a letter from his father, **Jonathon Frueh** worked the last seven years as a systems analysis engineer with Dynamics Research Corp. in Wilmington, Mass. Jonathon had been very active in environmental groups, serving on a federal planning commission concerning the future of the White Mountain National Forest. In addition, he was for several years a director and then treasurer of the Randolph Mountain Club in Randolph, N.H. . . . **Eric Umland** was killed in a small plane crash in southern California last November. At the time, Eric was completing a postdoc in physics at Caltech, and had just accepted a position at the Jet Propulsion Labs. Eric is survived by his wife of five years, Jaye. To the family and friends of both Jonathon and Eric, our sincere condolences.

I got a note from **Carol Pokodner Power**, who was about to finish maternity leave from her job as financial analyst at Martin Marietta Data Systems, Greenbelt, Md. Her son, Alexander Philip Power, was born on April 10, and must have been quite a handful—she writes, "Working full time is much easier than taking care of a newborn full time."

Some news from a recent telethon: **Phil Kesten**, a caller at the telethon, told me that he was planning to get married June 22 to Kathy O'Shea ("a California girl") in Atherton, Calif. (near Palo Alto). Phil is working on a postdoc in physics at Brandeis University in Waltham, Mass. . . . **Donald Choing** and his wife Nancy (a pharmacist from Boston who once had an extra ticket to a Celtics game—and so met Donald) bought a house in New Milford, N.J., just before their marriage a year ago. Now they're expecting their first child. Donald is working in mainframe sales and support for IBM in West Orange, N.J. . . . **Roy Haygood** reports that he is a senior project engineer at General Motors, working on a digital instrument panel for cars.

Maureen "Mimi" Montgomery Blake's son kept playing with the phone while we were talking, but somehow I managed to get some news. Mimi now has two kids (both redheads), Brandon (age 3) and Courtney (age 1). Mimi, while not parenting, works as special projects manager (software) for the Marketing Research Group of the Neilson Co., in Minneapolis. And, in her spare time (if any), the Blakes are renovating a house in St. Paul (built in 1912). . . . **Boris Ackerman** finished med school in 1981; he is now working on a fellowship in plastic surgery at Ohio State University Medical Center.

One final note from the telethon. As many of you know, the class is working on a tenth year reunion gift of $100,000 for a student aid fund. Right now, thanks to all of you and, of course, thanks to former class agent **Dave Woodruff** and current class agent **Diane Curtis**, we are more than two-thirds of the way there! Still, we only have two more years to raise another $33,000, so don't stop giving yet.

After a long search for a satisfying job, **Scott Tobias** seems to have found one that fits to a "T." "I am now part of a small design group at Image Graphics, Inc. in Fairfield, Conn. We design and manufacture electron beam recorders, which record images directly onto film using electron beams. Among other uses, they are used for accurately recording engineering drawings and for creating printing masters. This fits directly into my photographic and graphic arts/offset printing (LSC style) interests." Scott's wife Elaine Robin Graves, '79, is just returning to work after the birth of their second child, Matthew. Older brother Aaron (age 3) has already become "puter" literate, having mastered several *Sesame Street* games.

Scott Chase has left San Francisco and, in his words, has "*finally* returned to school—studying design theory and computer-aided design in architecture at University of California at Los Angeles, leading eventually to a doctorate. I'm currently working on CADD applications at Skidmore Owings & Merrill in L.A. After a seven-year northern Californian bias against southern California, I find I like it here much more than I expected." . . . **Donald McCord** writes that he has just started a new company in computer graphics. Details to follow, we hope.

Lastly, there's me. I have survived six months at my new job and still enjoy the craziness and headaches involved in working for University Hospital in Boston. Of course, a little less craziness might help, but such is life in today's hospital industry. My wife Yuko has her last final exam tomorrow (Sloan School), after which we are taking a well-deserved week-long vacation in California. 'Til next time, ciao baby. Send news, notes, fabrications, and boring postcards to me.—**David S. Browne**, Secretary, 50 Follen St., No. 104, Cambridge, MA 02138, (617) 491-5313

79

North of the border, **David Soule** has moved to Niagara Falls, Ontario, where he is the production manager for the Union Carbide processing department. For recreation, he has been playing tennis and sailing on Lake Ontario. . . . **Jeffrey Dugal** writes, "Finally got a couple of high oxygen barrier plastic containers in production now that I'm working for Rampart Packaging, a Shell subsidiary, in Williamsburg, Va. Think of me whenever you see Mott's Applesauce or Ocean Spray Cranberry Sauce in plastic containers."

Don Bender is the lead engineer on a high average power laser program at Livermore Laboratory, a key part of the S.D.I. Free Electron Laser. In his spare time: "extreme skiing (chutes, cornices, and cliffs) in the Sierras, plus keeping up on guitar playing, transcribing Bach piano works." . . . **Pamela Berry** received a Master of Laws in Taxation degree from Georgetown University Law Center in May 1985. She is currently an associate at Steptoe and Johnson in Washington, D.C., practicing federal tax law. . . . **Elaine Sears** is back in California after two years in Boston at the Harvard Business School. Writes Elaine, "I am working in marketing at Sun Microsystems, and thoroughly enjoying being part of a fast-moving, fast-growing company that has just recently gone public." . . . **Vijay Vazirani** got his Ph.D. from University of California, Berkeley, in 1983 is now an assistant professor of Computer Science at Cornell University's College of Engineering, specializing in efficient algorithms and computer complexity. Vijay was recently named a Presidential Young Investigator by the National Science Foundation, which guarantees him research funds for the next five years.

On May 3, I had the pleasure of serving as Maid of Honor at the wedding of Lori Ullman, '81, to Arnie Herman in Buffalo, N.Y. Lorie got her M.D. last year from the joint Dartmouth-Brown Medical Program, and is finishing an internship in internal medicine at St. Elizabeth's in Boston. She will soon be starting a dermatology residency at New England Medical Center. Arnie is a surgeon in Providence, R.I. The wedding was great fun and there were a lot of familiar faces there: Ed Moriarty, '75, and his wife Emily; fellow bridesmaid Karyn Altman Velazquez, '78, and her husband Ray; my colleague of these pages, Dave Browne, '78; Randy Forgaard, '81; Alice Tarbell

(Wellesley '81); Laura Green, Ph.D. '81, and her husband David Golan; Kumar Nochur, Ph.D. '85; and of course, my husband, Robert Lustig, '76.

While I was in Buffalo, I spent some time with my old friend Barbara Ostrov, '78, who is doing a residency in internal medicine and pediatrics at State University of New York at Buffalo. Next year she will be starting a rheumatology fellowship at the University of Pennsylvania in Philadelphia. . . . That's all for now. Hope to hear from more of you soon. (There's only so many weddings I can attend to fill up the column!)—**Sharon Lowenheim**, Secretary, 303 E. 83 St., Apt. 24F, New York, NY 10028

80

Lots of mail . . . thanks to everyone who sent in information this month!

Michel Floyd writes that he is now a senior research scientist at Integrated Systems, Inc., in Palo Alto, Calif. He is working in several areas including S.D.I., product development, marketing and advertising. He says that there are almost as many M.I.T. grads as Stanford grads there now. . . . **Bruce Allen** got his Ph.D. in 1983 at Cambridge University (yes, the one in the U.K.). He then spent two years as a post doc at U.C.S.B. in California and is now in the Physics Department at Tufts. He is marrying a French woman this summer and intends to spend January to July 1987 in Observatoire de Paris, Meudon. He will then return to Tufts the following year. . . . **R. B. Seidensticker** recently published his first book, *The Well-Tempered Digital Design*, and is an E.E. consultant. His daughter was 2 years old in May. . . . **James Talley** is employed as a senior construction specialist for Carolina Power and Light Co. at the Brunswick Nuclear Project.

Cyrus Taylor is currently a post-doctoral fellow in Physics at Rutgers University in New Jersey, where he is also teaching a course in superstring (I think—I can't read the handwriting) theory. . . . **David Kaus** is in the midst of an orthopedic surgery residency at the University of Texas Medical Branch in Galveston.

Gwen Freeman finished her Ph.D. at U.C. Berkeley last year and returned to the east coast to do post-doctoral work at Johns Hopkins University. She ran into Andy Gavain (he's in physics grad school there), whom she knew from Third East in East Campus. . . . **Calvin Winey** is a mechanical engineer for HowTek in Hudson, N.H. He won the 1984 *Design News* Excellence in Design award. . . . **Sherman Shlomo Elspas** writes from Harbor/U.C.L.A. Medical Center, "Anesthesiology fascinates me. I'm thinking of a subspecialty in the treatment of chronic pain after my residency."

Daniel Metzger is finishing his first year of pediatric residency training at Rainbow Babies and Children's Hospital in Cleveland. . . . **Kevin Riehl** writes that: (1) he is a captain in the Air Force; (2) he is finishing a master's in Physics at Wright Patterson A.F.B. in Ohio; (3) he is married with a 3-year-old son; (4) he spent five years in metropolitan Boston before moving to Ohio last spring; and (5) he is a member-at-large of the Alumni Basketball Conference.

Michael Bailin is an anesthesia resident at Mass. General. . . . **Robert Podoloff** is currently director of engineering for Sentek, Inc., a Cambridge start-up specializing in medical and dental instrumentation. . . . **Donald Brittain** married Skona Libowitz in June 1985 and has formed a company called Microcomputer Systems Consultants which develops A.I. and scientific software. . . . **Art Aaron** is a member of the class of 1987 at Harvard Law School.

Michael Abrams is employed as an electrical engineer at General Electric's Aerospace Electronics Systems Division in Utica, N.Y. He is also completing his M.S.E.E. at Syracuse University; his thesis topic is instrumentation for research in cardiac arrythmia. . . . **David Damery** has been a naval architect with Earl and Wright, Consulting Engineers (San Francisco) for five years. He married Connie Rugg (Lesley College '78) three years ago. He has been travelling a fair amount in this job (London; Houston). He will be attending grad school in business at Carnegie-Mellon University this fall and says "Hi" to all of the old crowd from Runkle, Senior House and the M.I.T. Hockey Club.

Debbe Utko is enjoying life in rural Pennsylvania. When she's not busy consulting, she works out or just relaxes, but she also has had a chance to teach evening courses to adults at a local four-year college in the area. She says, "The most frightening thing is that they take notes on what you say!" . . . **Leonard Sax** graduated from the University of Pennsylvania in May 1986 with an M.D. and Ph.D. In July he will start his family practice residency, probably in Lancaster, Pa. In the meantime, he is working on a book about flaws in the design of the normal human body ("shades of 8.013"). . . . **Scott Norton** finished his tour of duty on the cruiser U.S.S. Harry E. Yarnell in December, and has transferred to the Naval Postgraduate School in Monterey, Calif., where he'll spend two years studying for his M.S. in electrical engineering. He says he finds life as a grad student more relaxing than sea duty, and spends his free time taking trips to Napa Valley (or the Monterey area wineries), playing volleyball, and bicycling. . . . **Cliff Macfarland** writes to say that he has left his position in the Hazardous Waste Division of CH2M Hill Consulting Engineers in Gainesville, Fla., and is now a first-year law student at Columbia. He is very much enjoying being back in the northeast.

Finally, some news from the 'Tute itself: Two of our classmates are recently appointed faculty members. **Yet-Ming Chiang** is an assistant professor in Materials Science and Engineering. He completed his Sc.D. in Ceramics from M.I.T. in 1985. . . . And **Steven Hall** is now an assistant professor in the Department of Aeronautics and Astronautics. He received his Sc.D. in 1985.

As I read back through these notes I am fascinated (and proud) of all of the accomplishments of members of our class! Please keep us all informed of your own accomplishments and activities—don't forget to write! Thanks again to everyone who wrote in recently.—**Kate Mulroney**, Secretary, Index Systems, Inc., 5 Cambridge Center, Cambridge, MA 02142

83

Things have really been crazy here in New York. **Al Bashawaty** and I finally closed on our house. We originally bought the house in October, and it took us until May to close on the thing. . . . **Jeffrey Lipton** writes that he is finishing his third year at Jefferson Medical College in Philadelphia and will begin the long grind of looking for that magical residency for internal medicine. Jeffrey keeps busy by singing in the school choir and frequently has deja vu of his days with the M.I.T. Choral Society. . . . **Daisy Schrock** has been chosen as the Foreign Technology Division's company grade officer of the quarter at Wright Patterson Air Force Base, Ohio. . . . **John Roberts**, that Marine Corps madman, recently completed a four-week training course in air/ground combat. John's specialty was helicopter support. He is looking forward to putting his lab work into practical applications. . . . **David Herring**, not to be outdone by John, has also decided to strut his military prowess. David has been promoted to first lieutenant in the U.S. Air Force. David is still stationed in Cincinnati and hopes to be out and amongst the civilians as soon as possible.

Michael Cafferty has come out of the water and gone straight to Pennsylvania. He has decided to abandon Burroughs and attend Lehigh University in their electrical engineering Ph.D. program. Mike supports himself and seeks entertainment by trying to teach Lehigh students electromagnetic theory in one of their core courses. While Mike was at Burroughs, he received an M.S. in electrical engineering at University of San Diego. . . . **David Payne** decided to tie the knot with Annette Hulse, '84. They now reside in Billerica, Mass. David is working for a start-up called Cognition doing mechanical computer-aided engineering. . . . **Remy Malan** writes, "Working at Tektronix in Beaverton, Ore."

Andrew Ralston had a few more words to say, but was somewhat more ambiguous. Andrew is interested in raising his awareness level while trying to capture what the essence of man really is. By playing as an engineer, he can sufficiently disguise himself and carry on his own private research on how to proceed with his life. Let us know how you make out. . . . **Steven Eppinger** has become a father! His new daughter, Lauren Elizabeth, was born November 16 (of last year). He and his wife are extremely happy with the new addition. . . . **Michael "Metagraphics" O'Malley** has decided to make the big move. Since Michael has always been interested in CAD/CAM databases, he thought it was time to do something that he enjoyed. He now works as a software release manager for none other than MetaGraphics.

Robert Cox tells us that he enjoys southern California very much. Since he has been working as an engineer in the semiconductor components group of Northern Telecom Electronics, he has found time to relax with the women of southern California over double martini lunches. Bon appetite, Rob. . . . **John Pitrelli** is just a diehard. He is now in his 14th term at M.I.T., still working towards his Ph.D. in electrical engineering. The funny thing is that he is still enjoying it. . . . **Heidi Tocker** sent me a long-distance mailgram. She has been busy in Thailand constructing some 229 toilets. The Peace Corps has commissioned 145 toilets still to be built, and Heidi expects to be there for at least another year. She has also been accepted for a position in the U.S. consulate in Udornthani. If anyone wishes to drop her a note, she can be reached at Salakland Changwat, Amphu Muang, Udornthani 41000, Thailand.

Terry Sutton, now of the extremely, very tremendously prestigious Harvard Business School, called to say she was upset that she was named Celebrity 83. She is very happy at this exalted institution, and she is trying very hard not to become a stereotypical snob like Michael Moncavage, '82. Terry said it was a little early to talk about engagements but maybe by the time this column was printed the rumors could take a more solidified tone.

Now for that great honor . . . the Celebrity '83 for this issue. It goes to none other than **Jamshied Sharifi**. Jamshied was named outstanding pianist at Notre Dame's Collegiate Jazz Festival when he appeared with the M.I.T. Festival Jazz Ensemble. This years' competition featured two pieces commissioned by Jamshied. Jamshied is now in his second year at Berklee College of Music.

As for myself, I am still running and am now preparing for the corporate meets this summer. I will run with IBM's track team. It should be a lot of fun. The new address for me will be 14 Charles Ave., Port Washington, NY 11050. If you still want to send letters to Sayville, it is all right. I am in Sayville almost everyday. . . Keep the news coming.—**John E. De Rubeis**, Secretary, 47 Gillette Ave., Sayville, NY 11782

84

Hello classmates. This is **Mona Wan**—I just wanted to explain a little about this month's column. In the last column, I mentioned that we would be rotating columnists while Peter was out of the country. Well, this is still going to happen, only we have discovered one more column from Peter. So this month will feature Peter's column and next month shall be Diane's column. I hope that everyone in the class is happy with the way we have decided to handle Peter's absence. Again, if you would like to write and tell us what

you are doing, please send the letter to me, and I will forward the information to the column writer of the month. And now, here's Peter:

People often ask me how I "gather gossip" for these columns. The theory behind gossip gathering is relatively simple (i.e. keep your ears open, and write everything down), but developing good gossip gathering technique requires a great deal of practice. Extracting information can be refined to the level of an art form. And, of course, gossip gathering is useless without its complement, gossip dispensing—the mastery of which requires a ken for relating the most idle rumor in such a manner as to make it seem newsworthy.

"What about sources?" one might inquire. One source is obviously the mail I receive from you. For example, I just received a most interesting postcard from **Barry Surman**, who relates the following tale: "Following the tragic death of my Zen Master in a surfing accident, I moved to the beach so I can closely observe the seasonal migration of whales between Alaska and Baja California. It's been a good year for the humpbacks—the count is way up from last year. When the whales are away, I spend four or five days a week seeking universal truth in movies. Oh, yeah, I occasionally write for the *L.A. Times*, so I can keep the student loan payments up to date."

Without mail, I must resort to using my skills as an investigative reporter, cornering fellow '84ers and making them talk. One such cornered classmate was **Stu Gitlow**, who spilled the following: **Shigeki Misawa** is working on his Ph.D. in E.E. at Columbia; **Mike Burns** (sort of '84) finally graduated and is off to be a big-time computer consultant; and Stu is in his second year of med school at Mt. Sinai, running in his spare time Next House Software, a New York dealership in Macintosh software "formed to undercut 47th St. Photo and to make money."

And, of course, if I am really desperate for news, I resort to reading the notes submitted with your contributions to M.I.T. Former R/O Chairperson **Lillian W. Chiang** writes succinctly, "Where are the '84 notes?!" . . . **Martin I. Eiger**, who is working for Bell Communications Research, Exchange Network Research Division, in Morristown, N.J., echoes Lillian's thoughts with the comment: "Continue to read *Technology Review*, even though last several issues have not contained a column on the class of 1984." . . . **Kathy Takayama** writes, "I've gone back to school after taking a year off after M.I.T. and working for Biogen. Now it's five long years of the starving grad student life!" Kathy closes with the now all-too-familiar sentiment, "I'm disappointed that our class secretary has neglected a class of '84 section in the past two issues of *Tech Review*. What's the deal?!" (My apologies to one and to all.)

Alyssa Goodman tells us that she is in grad school in Physics at Harvard "living all the way at the other end of Cambridge." . . . **Steven Larky** announces that he has married Alexis Eve Solomon (Wellesley '84): "We had a wonderful time honeymooning in Italy. Am now very busy back at work at IBM Research, Yorktown." Former 20 Chimneys captain **Tony Riccobono** relates how he's moved up in the world: "I'm presently working for Hughes Aircraft in El Segundo, Calif., designing telemetry and command subsystems for satellites. I am also working on my master's at U.S.C. (Gary Wyetzner, '85, is in two of my classes), and I'm playing in a jazz band there."

Peter A. Russo informs us: "Upon graduating from M.I.T., I received my Regular Army commission as a Second Lieutenant in the U.S. Army. I was the Distinguished Graduate from the Signal Officer's Basic Course at Fort Gordon, Ga. in November 1984. Since then I have been assigned to the Information Systems Management Activity, Ft. Monmouth, N.J., where I have been involved in fielding strategic data communications worldwide for the Army."

Mark Peot, now a lieutenant in the Air Force, stationed at the Wright Patterson A.F.B. in Ohio and attached to the Advanced Development Group of the Electronic Warfare Division, reveals that he is working on "the Integrated Electronic Warfare System, EW signal processing and (for variety) UHF/VHF power amplifier design," as well as "antenna design and artificial neural system design." . . . We hear from **Jeff Collett**, who is in his second year of graduate study in Environmental Engineering Science at Caltech: "I've been busy studying acid fog all over Southern California which has given me a chance to familiarize myself with the many different attractions here." . . . **Van-Duc Nguyen** is doing research on grasping with dextrous hands in the Artificial Intelligence Laboratory, trying to "design a grasp expert that can synthesize stable grasps on arbitrary polyhedra." . . . We hear from **Mark Radlauer,** who tells us: "Having a great time with life. Still see lots of my friends. Wish I had a million dollars so I wouldn't have to take out so many loans for school."

As for me, your loyal secretary, I don't have a million dollars but I do have a job offer from Schlumberger. So, by the time you read this column, I may be out on an oil rig somewhere earning a living as a field engineer. Until next time, ciao!—**Peter Tu**, Secretary; **Mona Wan,** 12231 Viewoak Dr., Saratoga, CA 95070

85

Hello again! Here's the update on June grads from our class: **Dave Rose** finished and plans to make loads of money in New York City so he can retire at 35. . . . **Aaron Wang** has similar goals and will be in D.C. with Booz-Allen working as a consultant. . . . **Bill Maimone** and **Dave Douglas** finished their masters' degrees. Bill is heading west to Menlo Park, Calif.—he'll be working for Oracle. Dave will remain in the Boston area with Thinking Machines.

Chris Wright has abandoned Berkeley in favor of M.I.T., where he is continuing in Course VI grad school. . . . **Kathleen Wienholt** is also staying at M.I.T. to go for her Ph.D. in Computer Science. . . . **Todd Tskaris** will return to M.I.T. (hopefully for a short stay) after spending the summer in the Bay area. . . . **Larry Shapiro** will be attending Tufts in the Chemical Engineering department. He plans on staying near Boston and receiving his Ph.D. . . . **Ayay Nahata** is at Columbia working on his master's, presumably in E.E..

Soon to finish grad school are **Oliver Patterson** and **Gary Wyetzner**. Oliver will be leaving the University of Wisconsin to assume a position at Wright-Patterson A.F.B, in Ohio. I predict Gary will head back east after finishing at U.S.C.

Robert Watkins has been "cruising Arizona and Nevada." He met up with **Mark McEntee** and they visited **Hunter Thompson**. **Lars Rosenblad** is enjoying the southern California life. He works at Douglas Aircraft in Long Beach and is busy windsurfing. . . . **William Meeks** is working at Bell Communications Research. He is "designing and implementing a telephone service definition system for a prototype integrated communications environment."

Congratulations are in order for **Yet-Ming Chiang** (Sc.D. '85), who has joined the M.I.T. faculty as an assistant professor in Materials Science and Engineering. Yet-Ming's area of expertise is ceramics research. . . . The M.I.T. Festival Jazz Ensemble won many honors, due in part to **Greg Norris**, a drummer/percussionist who received an "outstanding performance award" and lead trumpet player **David Bondelevitch**. David's composition "Gary's Shoelaces" was performed by the band. David received a degree in Architecture from M.I.T. and a degree in film scoring from Berklee College of Music.

And congratulations to the newlyweds! **Richard Magahiz** (Ph.D. '85) married Pamela Finn, a recent graduate of University of Pacific's Weston School of Theology. Richard is an assistant professor of Physics at Union College in Schenectady. . . . **Mark Staples** will be married on August 2 to Barbara Fuertges of Danville, N.J. . . . The long-awaited marriage of **Charley Selvidge** and **Maureen Conners** occurred in June. Charley is continuing in E.E. at M.I.T. working towards his Ph.D. Maureen is working nearby at Draper Labs. . . . That's all folks!—**Stephanie Scheidler**, Secretary, 3511 Shafer Dr., Santa Clara, CA 95051, (408) 985-6651

86

A very belated congratulations on graduation. I hope everyone had an enjoyable summer. I'd like to send a hearty congratulations to **Stacy Thompson** and **Bob Malecki**, **Chris Clement** and Mike Lyons, '85, and **Dan Schmauch** and his fiancee—the first of our classmates to take the big step of marriage.

There seem to be a lot of ya'll who enjoyed school so much that you plan on staying there. Several have decided on medical school: **Dave Altshuler** at Harvard, **Andy Chess** at Columbia, **Costa Kokoropoulos** at the University of Illinois, **Alan Hilibrand** at Yale, and **Bob Noecker** at the University of North Carolina at Chapel Hill. . . . **Jennie Kwo** worked at Mattel this summer and has returned to M.I.T. for grad school in mechanical engineering. . . . **Jurgen Leschner** and **Siu Ng** are at the University of California at San Diego. Jurgen is working for his Ph.D. in computer science. . . . **Megan Smith** spent the summer traveling all over the U.S. with **Anne Fricker** and has returned to M.I.T. for her M.S. in mechanical engineering. . . . **Yong Mi Choi** is at Princeton working for her Ph.D. in chemistry. . . . **Mark Friend** spent the summer in Los Angeles and is back at the 'Tute finishing up his master's in Course 6. . . . **Kris Rothley** is at Cornell working for a master's in mechanical engineering and an M.B.A. . . . **Bill Brennan** is at Fordham University Law School. **Karl Tucker** and **Dave Richards** are at M.I.T. working for graduate degrees in Courses 16 and 6, respectively. . . . Finally, **Amy Reis** is attending the Sloan School at M.I.T.

The working sector should be settled into their jobs by now. We have a few classmates working on Wall Street: **Karen Wohl** is with Merrill Lynch; **Buzz Moschetti** is with Salomon Brothers; and **Felipe Medina** and **Robin Maury** are with Shearson Lehman. . . . **JT Lam** is working for an investment banking firm in New York City. . . . **Chris Clement** is with Xerox in Rochester, N.Y. . . . **Cary Ching** is with IBM in New York. . . . Boston also seems to be a popular work site. **Brian Miller** is working for Bain and Co. . . . **Ellen Epstein**, who spent the summer working in Andover, is with Cambridge Business Systems. . . . **Lauren Seeley**, who traveled with **Shawna Vogel** to Greece over the summer, is working for NOVA out of WGBH, Channel 2, Boston.

Jim Egan is working for Turner in civil engineering. . . . **Dan Pyne** is down in Washington, D.C., working for ICF Technologies. . . . **Yona Kaplan** is out in Detroit working for TMS. . . . Also in Detroit is **Stuart Schmill**, who is employed by GM. . . . **Miriam Maxian** is at XENERGY in Burlington, Mass. . . . **Dan Schmauch** is in Colorado Springs with Hewlett-Packard. . . . **Uki Kimura** is at Data General in Durham, N.H.

As for my air force friends who are all newly commissioned second lieutenants: **Marilyn Oberhardt** is at Hanscom AFB, which is fairly close to M.I.T. . . . **Lizet Tirres** and **Brett Pichon** are in Illinois. . . . **Matt Phelps** and **Don Davidoff** are at Norton AFB in California. . . . **Jim Nugent**, **Rich Maurer**, and **Jim Wilkerson** are anxiously counting the days until their pilot training begins. . . . **Nancy Kirwan** is at Pearl Harbor, Hawaii working with computers. Watch out, Nancy, we're all coming to visit.

To wrap up, I'd like to hear from everyone, if not for the column, then to keep in touch. Also, if you're interested in being a local or regional coordinator for the class, drop a line. I'll head to Los Angeles to work for the air force's space division. However, mail can always be sent to the following address.—**Mary E. Cox**, Secretary, 14317 N. Brook Dr., Dale City, VA 22193, (703) 670-2289

I CIVIL ENGINEERING

Peter S. Eagleson, Sc.D.'56, Edmund K. Turner Professor of Civil Engineering at M.I.T., is president-elect of the American Geophysical Union, which represents research-oriented geophysicists in the fields of atmospheric sciences, geodesy, geomagnetism and paleomagnetism, hydrology, ocean sciences, planetology, seismology, solar-planetary relationships, techonophysics, and volcanology. **Athelstan F. Spilhaus, Jr.,** '59, who holds three M.I.T. degrees in the field of geology, is AGU's executive director.

Richard A. Conway, S.M.'57, corporate development fellow with Union Carbide Corp., South Charleston, W.Va., has been elected a member of the National Academy of Engineering last February. Conway was cited "for outstanding contributions to environmental engineering through improved standards of assessment, and for development of improved water treatment processes for industrial wastes."

Professor Emeritus **John M. Biggs,** S.M.'47, of M.I.T. is the author of *Introduction to Structural Engineering: Analysis & Design*. The text is based on a beginning course in structural engineering taught by Biggs at M.I.T. . . . **Rodney P. Plourde,** Ph.D.'71, vice-president and director of Fay, Spofford and Thorndike, Lexington, Mass., is concluding his term as president (1985-86) of the Boston Society of Civil Engineers. . . . **Robert F. Lathlaen,** S.M.'46, president of W.J. Barney Corp., New York City, a leading construction firm, has been elected to the Board of Directors of the American Arbitration Association. Lathlaen, associated with W.J. Barney since 1946, is also a national director of the Associated General Contractors of America, past president of the General Building Contractors of New York State, and has been a member of the Board of Governors of the New York Building Congress.

II MECHANICAL ENGINEERING

Two major awards came to members of the department at M.I.T. from the Society of Manufacturing Engineers late last spring: to Professor **Nam P. Suh,** S.M.'61, the F. W. Taylor Research Award for "basic contributions in manufacturing research"; and to **George Chryssolouris,** associate director of the M.I.T. Laboratory for Manufacturing and Productivity, the Young Manufacturing Engineer Award for outstanding contributions by a younger practitioner. Suh is on leave from M.I.T. to serve as director for engineering at the National Science Foundation.

Roger S. Reiss, (S.B.'55), an opto-mechanical engineer at Aeroject ElectroSystems Co., Azusa, Calif., is an enthusiastic member of an *ad hoc* committee to establish an Opto-mechanical Engineering Group in the Society of Photo-Optical Instrumentation Engineers. Its purpose is to exchange information between mechanical engineers "who are currently involved in the design of precision optical instruments or opto-mechanical devices." The working group will host a reception at SPIE's annual meeting in San Diego on August 18 at 5 p.m. at the Town and Country Hotel. If interested, call the SPIE at (206) 676-3290.

John A. Clark, Sc.D.'53, writes, "I continue as professor of mechanical engineering at the University of Michigan, Ann Arbor, and am active in consulting work in the field of energy. I also serve as technical director of Starpak Energy Systems, Inc., at Novi, Mich." . . . **Edward Sziklas,** S.M.'53, assistant director of research for planning and division coordination at United Technologies Research Center, East Hartford, Conn., has been named one of eight recipients of the George Mead Award for Engineering Achievement. The award, in memory of United Technologies' first vice-president for engineering, cited Sziklas for his "advanced development work on high-power lasers. . . ."

Gary J. DesGroseilliers, S.M.'78, a liaison officer in the Industrial Liaison Office at M.I.T. (since 1981) has been promoted to senior liaison officer. Prior to DesGroseilliers' appointment at M.I.T., he was a member of the risk management staff of Arthur D. Little, Inc., Cambridge. . . . **Serope Kalpakjian,** S.M.'53, writes, "My book *Manufacturing Processes for Engineering Materials* (Addison-Wesley, 1984) won the 1985 M. Eugene Merchant Manufacturing Textbook Award. I am also the co-author of *Lubricants and Lubrication in Metalworking Operations* (Marcel Dekker, 1985)." . . . **Howard C. Merchant,** S.M.'57, president and principal engineer of MerEnCo, Inc., Bellevue, Wash., has been named a fellow of ASME. Merchant has been active in the field of vibrations, dynamics, acoustics, and earthquake engineering.

Adrian Bejan, Ph.D.'75, professor of mechanical engineering and materials science at Duke University, Durham, N.C., writes, "I served as invited keynote speaker at the Second Latin American Congress on Heat and Mass Transfer, held in Sao Paulo, Brazil, May 12-15, 1986. The title of my opening address was 'Buckling Flows: A New Frontier in Convection Heat Transfer Research.' " . . . **Herbert H. Richardson,** Sc.D.'53, vice-chancellor and dean of engineering at Texas A & M University, College Station, has been elected a councillor of the National Academy of Engineering for a three-year term, effective last July 1.

Two deaths have been reported to the Alumni Association with no further details available: **Douglas R. Arnoldi,** S.M.'67, of Southbury, Conn., on October 25, 1985, after a brief illness; and **Hasmukh P. Oza,** S.M.'46, of Ahmedabad, India, on August 4, 1985.

III MATERIALS SCIENCE AND ENGINEERING

Maryann C. Kenney, Ph.D.'83, **John F. Mandell,** Ph.D.'71, and **Frederick J. McGarry,** S.M.'53, are co-authors of "Fatigue Behaviour of Synthetic Fibres, Yarns, and Ropes" in the *Journal of Materials Sciences*, Volume 20 (1985). Kenney is now associated with the Albany International Research Co., Dedham, Mass., Mandell and McGarry with the department at M.I.T.

George W.P. Rengstorff, Sc.D.'50, professor of chemical engineering at the University of Toledo, (UT) retired last June 14. Rengstorff joined UT from Battelle Memorial Institute in 1969 to work in materials science, corrosion, and the heat treatment of metals. Since then Rengstorff has made important contributions to metallurgy teaching and research, receiving a special award by the American Foundrymen's Society; and served as chairman of the UT Engineering Physics Program. Rengstorff's retirement plans include renewing his interests in playing bridge, collecting stamps, gardening, and camping. "I have plenty to do," he says.

IV ARCHITECTURE

A new honor for **I. M. Pei,** B.Arch.'40: a 1986 honor award of the American Institute of Architects for his firm's design of the IBM Corporate Office Building in Purchase, N.Y.—"a finely crafted, dignified expression of modern architecture," said the jury. "The calm, richly elegant interior spaces are superbly organized and are energized by an infusion of sun-drenched light."

Arnold G. Gangnes, M.Arch.'46, writes that he was scheduled to address an Inter-American Conference on Mental Retardation in Buenos Aires in August, on the subject of housing for the physically and mentally handicapped. His assignment also included a week-long seminar and an exhibit on the same topic; and he planned to attend the World Congress of the International League of Societies for the Mentally Handicapped in Rio de Janeiro, also in August.

E. L. Wick

F. W. Collins

V CHEMISTRY

Robert L. Letsinger, Ph.D.'45, who is professor of chemistry at Northwestern University, was honored late last spring by election to the National Academy of Sciences.

Edward R. Kane, Ph.D.'43, director and former president of the Du Pont Co., has been elected to a four-year term as treasurer of the National

Academy of Engineering. He succeeds **Frederic A. L. Hathaway** (Sc.D.'39 Course X), retired vice-president for science and technology at Exxon, who has been NAE treasurer since 1977 and for six years previously was a member of the NAE Council.

Two alumnae of the department retired from the faculty of Mount Holyoke College on July 1: **Emily L. Wick,** Ph.D.'51, professor of chemistry and special assistant to the president for long-range planning; and **Frances M. Collins,** Ph.D.'48, lecturer in chemistry and director of the chemical laboratories. Collins first taught at Mount Holyoke in 1948-49, returned for ten years in 1958, and joined the college once more in 1977. Wick's undergraduate degree is from Mount Holyoke, to which she returned in 1973 to be dean of the faculty; meanwhile, she had joined the M.I.T. faculty following graduate study, and she was the first woman at M.I.T. to be promoted through the ranks to full professor with tenure.

Bennett N. Epstein, Ph.D.'56, a research scientist at the Du Pont Experimental Station, Wilmington, Del., has been promoted to department fellow, Du Pont's highest rank for a research scientist. Epstein, who joined Du Pont in 1949 and works in the field of engineering plastics, was cited for "his ability to unite basic science and innovative product technology with realistic business planning." His most significant contribution was the "invention of super-tough nylon engineering resins." . . . **Thomas McCarthy,** Ph.D.'82, of the Department of Polymer Science and Engineering at the University of Massachusetts, Amherst, was among 100 scientists (nationwide) to receive a Presidential Young Investigator Award.

David W. Ellis, Ph.D.'62, president of the 2,300-student Lafayette College, Easton, Penn., was selected one of four candidates for the position of chancellor of the University System of New Hampshire. Ellis formerly served (for 16 years) at the University of New Hampshire as chemistry professor and academic vice-president. . . . **S. Donald Stookey,** Ph.D.'40, a retired Corning Glass Works chemical research scientist, was awarded a 1986 National Medal of Technology for his contributions to glass and ceramic technology at White House ceremonies last spring. Stookey's pioneering efforts to control crystallization in amorphous glass led him to develop an entirely new family, which he now holds 60 patents, including applications in a number of Corning products.

VI ELECTRICAL ENGINEERING AND COMPUTER SCIENCE

Cecil H. Green, S.M.'24, received Oxford's honorary degree of doctor of science as founder and honorary fellow of Green College, Oxford University, on June 25. It is Oxford's only college dedicated to the study of medicine.

To honor **Robert R. Everett,** S.M.'43, upon his retirement as president of MITRE Corp. last June 1, MITRE and a group of Everett's friends and colleagues established an endowment fund in Everett's name at Duke University, the institution from which he entered M.I.T. in 1941. Everett has been a long-time member of the Duke School of Engineering's Board of Visitors and Dean's Council. Income from the fund is to be used for teaching and research equipment.

Two major awards of IEEE came to alumni of the department last spring: the Alexander Graham Bell Medal to **Bernard Widrow,** Sc.D.'56, professor of electrical engineering at Stanford; and the Edison Medal to **James L. Flanagan,** Sc.D.'55, director of the Information Principles Research Laboratory at AT&T Bell Laboratories. Widrow's citation is "for fundamental contributions to adaptive filtering, adaptive noise and echo cancellation, and adaptive antennas"; Flanagan's "for a career of innovation and leadership in speech communication science and technology."

Forecast for Forecasting: More of the Same

After closely monitoring the weather radar atop the Green Building for a full 40 minutes early on the morning of this year's graduation exercises, an M.I.T. meteorologist predicted "showers around 10 A.M., then the storm will move out to sea" (*see page MIT 5*). The storm did move, but a new outbreak of rain moved in rapidly from the south and settled, to all appearances, right over Killian Court.

Such upsets in short-range weather prediction are not uncommon. An 18-year study (1966-1984) conducted by M.I.T. faculty and meteorology students found that the techniques for predicting a rainstorm within 24 hours "haven't improved much for nearly two decades." Professor Emeritus Frederick Sanders in the Department of Earth, Atmospheric and Planetary Sciences found that because of the complexity of weather systems, the 85 percent success rate of predicting rain has remained nearly constant throughout this period.

"If you simply predict no rain every day for Boston," Sanders said in an article in *Science '86* (June), "you would be right 65 percent of the time." Because of improvements in weather satellites and computer technology, it is easier to track storms two or three days ahead. But short-term predictions are still based on changes in temperature, wind direction, humidity, barometric pressure, and, to be safe rather than sorry, "looking out the window," says Sanders.—*Valerie Kiviat* □

Professor Emeritus Frederick Sanders' academic focus carries over into his retirement activities, as he measures local rainfall with a rain gauge in the backyard of his Marblehead, Mass., home.

Two M.I.T. alumni had featured roles in satellite-broadcast courses in manufacturing systems engineering sponsored by the National Technical University early in August. **Richard Giglio,** '59, head of the Department of Industrial Engineering and Operations Research at the University of Massachusetts, Amherst, was in charge of the unit on economic decision-making for manufacturing, and **Roger A. Holmes,** S.M.'58, director of engineering at Sciaky Brothers, Inc., Chicago, spoke on robotics in welding.

Professor **Mildred S. Dresselhaus,** who holds M.I.T. appointments in both electrical engineering and physics, was selected late last spring for the 1986-87 James R. Killian Jr. Faculty Achievement Award to recognize "extraordinary professional accomplishments and service to the Institute." Earlier last year Dresselhaus had been nominated by her faculty colleagues for the title of Institute Professor. Dresselhaus will also serve as a Phi Beta Kappa visiting scholar in 1986-87, travelling to campuses throughout the United States to give lectures and class discussions. Another honor for Dresselhaus: she has been elected to the Board of Directors of Rogers Corp., Rogers, Conn.

Jeffrey H. Lang, Ph.D.'80, associate professor of electrical engineering at M.I.T. who's an expert in electromechanical systems, was the 1986 recipient of the Harold E. Edgerton Faculty Achievement Award for "outstanding contributions to research, teaching, and the Institute community." . . . Meanwhile, four of Lang's M.I.T. colleagues were named by the National Science Foundation to receive Presidential Young Investigator Awards: Assistant Professor **Robert C. Berwick,** Ph.D.'82, working in the field of artificial intelligence and natural language processes; Assistant Professor **James G. Fujimoto,** Ph.D.'84, on optical and electrical processes; Assistant Professor **Roger T. Howe** on solid-state devices; and Assistant Professor **John N. Tsitsiklis,** Ph.D.'85, on systems theory.

To Professor **Thomas H. Lee,** who's on leave from the department at M.I.T. to serve as director of the International Institute for Applied Systems Analysis (IIASA) in Laxenburg, Austria, the 1986 Davies Medal for Engineering Achievement from Rensselaer Polytechnic Institute.

Lee is co-author, with **John C. Fisher,** Sc.D.'47, of "Is Your R&D on Track?" in *Harvard Business Review* for January/February 1986—a proposal for "evaluating and controlling R&D projects and programs through . . . five key issues": strength, timing, fit, responsiveness, and robustness.

PHOTO: PAULA M. LERNER

VI-A Internship Program

Rain and more rain was the order of the day for graduation on June 1. Activities proceeded undaunted, however, and we had one of our largest groups of VI-A students ever to graduate (approximately 80 undergraduates and graduates.)

Three VI-A graduate students were recipients of teaching awards given out at the department's annual spring gathering on May 18. Because of the increasing size of this gathering it could no longer be held at M.I.T.'s Endicott House in Dedham and so was moved to the new west wing of Boston's Museum of Fine Arts. Recipient of the **Carlton E. Tucker,** '18, Teaching Award was **Franklyn A. Turbak,** '84, who was also promoted to instructor. **Ann N. Tulinsteff,** '83, received a **Frederick C. Hennie,** '55, Teaching Award, as did **Forrest J. Thiessen,** '84. Ann was also promoted to instructor.

Undergraduates were also honored at the department social and, again, VI-A'ers were recipients. The **Ernst A. Guillemin,** '24, Awards for Outstanding Senior Theses included: **Saed G. Younis,** '86, winning the first prize and **Roy I. Vandermolen,** '86, winning an honorable mention. For best undergraduate thesis in computer science, **Manyan Henry Wu,** '86, was the winner.

Two VI-A traditions will be continued this summer. The eighth annual VI-A West Coast picnic is scheduled for August 10 in Mountain View, Calif. Last year was the first year the M.I.T. Club of Northern California ran the affair jointly with VI-A and it was a great success—a good chance for alumni to meet our current students, of whom 37 are on the West Coast this summer. This year the Alumni Club is inviting new Bay area freshmen to join the picnic to give them some background prior to their coming to M.I.T. The Club felt these new students would glean more current information by talking with our present students than just with alumni. Certainly an important added function we're glad to incorporate in this popular affair! The second continuing tradition is the Texas Instruments VI-A Luncheon in Dallas hosted by **Cecil H. Green,** '23, himself a product of VI-A. Our new associate director, **Kevin J. O'Toole,** '57, will be attending both of these functions for the first time, and I hope many of our alumni will become acquainted with him.

Those who we've seen at the Institute, or who have contacted us otherwise, include the following (alphabetically):

Jerome L. Abel, '60, told us he was to be married in June in the M.I.T. Chapel. . . . **John D. Chisholm,** '75, stopped by on his way back to California from Europe. He planned to be co-chair of the VI-A West Coast picnic again this year. . . . **Francis P. Corr,** '84, writes that he is living in San Jose and is with IBM's new Santa Theresa Lab., also in San Jose. . . . **E. Thomas Craig,** '81, with ROLM Corp., Santa Clara, Calif., tells us that his wife had a daughter on May 7. . . . **A. George Foyt,** '59, represented United Technologies, Inc., at M.I.T.'s VLSI Spring Review last May 19-20.

Joseph L. Healey, '77, stopped by; he, **Jeffrey J. Held,** '76, and **L. David Passmore,** '77, all work for Networks Systems, Inc., Fairfax, Va. . . . **David A. Krall,** '83, is with Optima, Burlington, Mass., and stopped by for a visit. . . . **Philip O. Martel,** '71, stopped by with his wife but missed John Tucker; however, during a recent visit to General Electric, Pittsfield, Mr. Tucker looked him up and had a nice chat. . . . **Andrew E. Moysenko,** '72, came by to say he's associated with Sanders/MEC, Nashua, N.H. . . . **Mark N. Seidel,** '83, came by and visited from Winchester, Mass. . . . **Richard S. Withers,** '75, came in from Lincoln Laboratory where he's had some VI-A students working in his group. . . . **Gerald G. Wong,** '83, stopped by one afternoon. He's with AT&T Bell Labs.

Our alumni/ae contacts are wonderful—keep them up. Drop us a note of interest!—John A. Tucker, Director, VI-A Internship Program, M.I.T., Rm. 38-473, Cambridge, MA 02139

VII BIOLOGY

Professor **David E. Housman** and his collaborators in the department at M.I.T. are credited by *Science* magazine with the first evidence that manic-depression, a relatively common mental disorder, has a genetic basis. Though comparisons of the DNA of afflicted and non-afflicted people have not yet revealed the location of the gene related to manic-depression, Housman and his group have eliminated as possibilities a number of chromosomes.

Two members of the department's community were honored by election to the National Academy of Sciences late last spring: Professor **Ira Herskowitz,** Ph.D.'71, who is vice-chairman of the Department of Biochemistry and Biophysics in the University of California School of Medicine, San Francisco; and Professor **Susumu Tonegawa** of the M.I.T. Center for Cancer Research.

To Professor **David Baltimore,** director of the Whitehead Institute, an hononary degree of doctor of science from Atlanta University. Baltimore was cited as an "eminent scientist, (and a) thoughtful advocate of responsible scientific research." . . . And to **Phillip A. Sharp,** director of the Center for Cancer Research, the $100,000 Alfred P. Sloan Prize of the General Motors Cancer Research Foundation, given for the most significant recent basic research advance clarifying the underlying nature of cancer.

Ward J. Haas, Ph.D.'49, who has directed major corporate research and development operations for over 20 years, has been named president of the University of Bridgeport's Industrial Research Corp. . . . **Iris C. Anderson,** S.M.'63, writes, "I've been doing lots of travelling; measuring emissions of nitrogen trace gases into the atmosphere for NASA's Langley Research Center. I'll be visiting Cambridge this summer with my daughter, who is interested in attending M.I.T."

Cynthia J. Kenyon, Ph.D.'82, formerly a scientist at the Medical Research Council, Laboratory of Molecular Biology, Cambridge, England, has been named one of two 1986 Searle Scholars by the University of California, San Francisco. Kenyon joined the University's Department of Biochemistry in June to work on the genetics of development and differentiation in the nematode worm. . . . **Irvin T. Olsen,** '43, of Hendersonville, N.C., passed away on February 15, 1986; no further details are available.

VIII PHYSICS

To **Jerrold R. Zacharias,** Institute Professor Emeritus at M.I.T., and the I. I. Rabi Award of the 1986 Frequency Control Symposium for outstanding contributions in the fields relating to atomic and molecular frequency standards. The prize recognizes Zacharias' major work in two related fields of interest—the electric and magnetic shapes of atomic nuclei and atomic clocks.

Physics Through the 1990s, an eight-volume survey of recent research progress, opportunities and challenges commissioned by the National Academy of Sciences, had major contributions from the M.I.T. community. Professor **Ronald C. Davidson,** director of the Plasma Fusion Center, served on the committee that oversaw the project and was co-chairman of the panel that planned and wrote the volume on *Plasmas and Fluids.* Professor **Daniel Kleppner,** also a member of the oversight committee, was chairman of the panel preparing the volume on *Atomic, Molecular, and Optical Physics.* Other contributors to the series included M.I.T. Professors **Robert W. Field, George Bekefi,** and **Mildred Dresselhaus.** The books, written to be understood at the M.I.T. undergraduate level, according to Davidson, are available from the National Academy Press in Washington.

A new honor for Professor **Daniel Kleppner** last spring: election to the National Academy of Sciences.

"Research Needs for Standards Development Regarding Noise in the Workplace" was the title of an invited paper by **Kenneth McK. Eldred,** '50, of Ken Eldred Engineering, Concord, Mass., at the spring 1986 meeting (Cleveland) of the Acoustical Society of America. His subject: "the research tasks and objectives required to support a comprehensive standards development effort."

T. Marshall Hahn, Jr., Ph.D.'50, chairman and CEO of Georgia-Pacific Corp., was principal speaker last May at commencement exercises of Atlanta University. His theme: though today's structured society tends to submerge the individual and emphasize group accomplishments, that's illusory. "The choices you make, . . . the habits of work and behavior you establish in the years ahead," Hahn told the graduates, "will not only determine the contribution and satisfaction of your own lives, but will influence whether our free society can continue to prosper, or perhaps survive."

To **Robert J. Hansman, Jr.,** Ph.D.'82, Boeing Assistant Professor of Aeronautics and Astronautics at M.I.T., a Presidental Young Investigator Award from the National Science Foundation. Hansman will use his prize for work in aerospace engineering; the awards are intended to fund research by faculty members at the beginning of their careers.

Albert Wheelon, Ph.D.'52, former president of Hughes Aircraft Co.'s Space and Communications Group, (Los Angeles, Calif.) has been elected executive vice-president—operations for Hughes Aircraft. In this newly created position, Wheelon will be responsible for the operations of the firm's major organizations. . . . **J. Lambert Bear,** Ph.D.'60, reports, "I am still manager of nuclear design at the Knolls Atomic Power Laboratory, Schenectady, N.Y., which General Electric operates for the government. Our current project is the design of the Advanced Fleet Reactor. My two children are now grown and away from home."

Merrill L. Andrews, Ph.D.'68, is chairman of the Physics Department and director of engineering physics at Wright State University, Dayton, Ohio. . . . A member of the department and an alumnus were awarded prizes by the American Physical Society, last April 28-May 1: Professor **Daniel Kleppner** received the 1986 Davisson-Germer Prize, cited "for his innovative and pioneering studies of the fundamental properties of the Rydberg atoms and their interactions with electromagnetic fields"; and **Elias Burstein,** '43, Mary Amanda Wood Professor of Physics at the University of Pennsylvania, received the 1986 Frank Isakson Prize for Optical Effects in Solids, cited for "pioneering work on the optical properties of semiconductors and insulators." . . . **Jerome Apt III,** Ph.D.'76, is mission specialist astronaut at NASA's Johnson Space Center, Houston, Tex.

Leslie Horwitz Lynn (Course XV, S.M.'72) writes to inform us that **Jeanne Horwitz Fertel,** Ph.D.'69, passed away on March 9, 1986. Leslie writes, "Jeanne made her home in Hawaii after leaving Cambridge and was extremely active in community affairs and politics." . . . **Rex G. Fluharty,** Ph.D.'49, of Los Alamos, N.M., passed away on April 26, 1985.

X CHEMICAL ENGINEERING

Lyle C. Jenness, '37, retired head of the Chemical Engineering and Pulp and Paper Departments at the University of Maine, Orono, passed away on May 4, 1986. Jenness's University career spanned 41 years after his graduate study at M.I.T. and led to the dedication of a building in his honor in 1970. Following retirement, Jenness served as executive director of the University of Maine Pulp and Paper Foundation; in 1972 he was named medalist by the Technical Association of the Pulp and Paper Industries. . . . Two deaths have been reported to the Alumni Association with no fur-

Loren R. Graham (left), professor of the history of science in the M.I.T. Program on Science, Technology, and Society, is congratulated by Purdue University president Steven C. Beering upon receiving Purdue's honorary doctor of letters degree last June. Graham is also visiting professor at Harvard.

ther information available: **J(ohn) Theodore Acker,** S.M.'24, of Bethlehem, Penn., on November 3, 1985; and **Laxton M. Smith,** S.M.'36, of Venice, Fla., on December 15, 1985.

XI URBAN STUDIES AND PLANNING

Ruth Kolodney, M.C.P.'81, writes, "Dividing my time between my daughter Giuliana and my job at Comunitas, Inc., Boston, where I am a planner."

William B.S. Leong, M.C.P.'48, a civil engineer, landscape architect, and city planner, passed away on March 17, 1986. Leong served as a planning officer for Haverhill, Mass., (1958-1961) and in a similar position for Lowell, Mass., until 1966. Leong then spent six years as a consultant to Aid for International Development in Pakistan and Thailand. He then joined the planning departments of the Boston and Manchester offices of the Department of Housing and Urban Development until his retirement in 1985.

Professor **Bernard J. Frieden,** Ph.D.'62, was honored by his M.I.T. faculty colleagues late last spring: he is now starting a two-year term as Chairman of the Faculty. . . . Two deaths have been reported to the Alumni Association with no further details available: **Ralph H. Baker, Jr.,** S.M.'47, of Neptune Beach, Fla., on July 7, 1985; and Professor **William A. Wintz, Jr.,** of Baton Rouge, La., in 1985.

XII EARTH, ATMOSPHERIC, AND PLANETARY SCIENCES

To Associate Professor **Kerry A. Emanuel,** Ph.D.'78, of M.I.T. the Clarence Leroy Meisinger Award of the American Meteorological Society "for highly original advances in mesoscale meteorological theory and interpretation of observations." Emanuel's current research includes work on the dynamics of rainbands and coastal fronts.

The Waldo E. Smith Award "for extraordinary service to geophysics" came to **Thomas F. Malone,** Sc.D.'46, at the spring 1986 meeting of the American Geophysical Union. Malone, who is scholar in residence at St. Joseph College, West Hartford, Conn., was cited for his "skillful leadership to AGU activities over many years."

"I try to spend at least three months each year in remote mountainous environments doing field work and savoring the virtues of the particular indigenous culture," Professor **Peter Molnar** of M.I.T. told the editors of *Scientific American.* Among the fruits of that discipline are an article for *Scientific American* for July: "The Structure of Mountain Ranges"; and for *American Scientist* for March-April: "The Genetic History and Structure of the Himalaya."

James L. Powell, Ph.D.'62, president of Franklin and Marshall College, Lancaster, Penn., received an honorary doctorate from the Tohoku Gakuin University, Sendai, Japan, last May 15. Tohoku Gakuin University, founded by two F&M alumni, has been closely tied with F&M for more than a century. . . . **Charles T. Prewitt,** Ph.D.'55, formerly professor of earth science and materials science at the State University of New York, Stony Brook, became director of the Geophysical Laboratory at the Carnegie Institution of Washington last July 1.

James F. Scheimer, Ph.D.'79, reports, "I am taking leave from my position at Lawrence Livermore National Laboratory to take the post of director of the Data Management Center for the Incorporated Research Institutions in Seismology in Rossyln, Va." As of that writing, he expected to make the move in August."

XIII OCEAN ENGINEERING

Frank J. Graziano, S.M.'45, retired from his post as chairman of Crompton and Knowles Corp., New York City, last March 31. . . . **David S. Greeley,** Ph.D.'82, writes that he is "now a vice-president of Atlantic Applied Research Corp., Burlington, Mass., in charge of computational fluid dynamics for the *America II* America's Cup challenge—trying to get the America's Cup back from the Australians." . . . Captain **Francis B. Merkle** (U.S.N. Ret.), S.M.'41, of Bethesda, Md., passed away on March 8, 1986.

XIV ECONOMICS

Robert L. Lerman, Ph.D.'70, senior research associate at the Heller Graduate School at Brandeis University, Waltham, Mass., one of two winners of a national essay contest to blueprint a reform of the nation's welfare and social assistance programs. Lerman's ward from the Institute for Economic Studies was for his essay "Separating Income Support from Income Supplementation." In his winning essay, Lerman argued that a comprehensive program relying on a universal income supplement cannot win public support. The willingness of able-bodied adults to work, the presence of children, the health of the family members, the availability of assets, and the family's living costs are among additional factors important to the public.

XV MANAGEMENT

Private-sector technology strategy is the subject of Professor **Mel Horwich** of M.I.T.—a chapter in *Competitiveness Through Technology*, edited by Professor Jerry Dermer of York University (Lexington Books, D.C. Heath and Co., 1986).

Alan J. Zakon, S.M.'59, has resigned from his post as chief executive officer but retains his office of chairman of the Board at Boston Consulting Group.

Gary S. Hom, S.M.'81, writes, "Four years after leaving Sloan, I'm still with Citicorp/Citibank. I'm now an assistant vice-president. Two things have been taking up my time and effort during the past few months: a three-week trip through the People's Republic of China with my wife; and spearheading microcomputer applications development for a Citibank business unit of 1,600 employees." . . . **Charles T. Harris III,** S.M.'80, is vice-president—corporate finance at Goldman, Sachs and Co., New York City. . . . **Vince Castellano,** S.M.'77, writes, "My son Charles turned one-year-old in December 1985. This is an unbelievable experience and I wouldn't trade it for anything." . . . **Perry D. Cohen,** Ph.D.'79, reports, "I have expanded the offices of my management consulting firm of Perry Cohen and Associates in a new location at 4400 East-West Highway, Bethesda, Md."

Linda Kay Smith, S.M.'79, founder and former chairman of the Achievers, Inc., Boston, has been appointed an industrial liaison officer at M.I.T. Smith has earlier worked for Lotus Development Corp., Digital Equipment Corp., and the John Hancock Mutual Life Insurance Co. . . . **Stanley M. Proctor,** '43, founder of the Stanley M. Proctor Co., Twinsburg, Ohio, has announced a major transition in leadership: he will assume the responsibilites of chairman, and his son **John D. Proctor,** S.M.'73, formerly executive vice-president, will be president and chief executive officer. . . . **Lucille D. (Schecht) Roseman,** S.M.'72, treasurer at Xenergy, Inc., Burlington, Mass., a computer company, passed away on November 17, 1985; she was 51. No further details are available.

Sloan Fellows

James G. Cosgrove, S.M.'85, and **Ubiratan N. Guzzi,** S.M.'85, were announced early this year as winners of the 1985 Brooks Prize for the Sloan School's best master's thesis. Cosgrove and Guzzi were co-authors of "Risk Free to Risk Taking: Developing the Renaissance Manager."

For "key contributions to research in the advancement of manufacturing technologies," **Robert P. Clagett,** S.M.'67, was named to the National Academy of Engineering early this spring. Clagett is former general manager of research and development at AT&T Technologies, Inc., Princeton, N.J.

Richard J. Santagati, S.M.'79, former president and chairman of NYNEX Business Information Systems, has joined the firm of Gaston Snow and Ely Bartlett, Boston, and will serve on Gaston Snow's Executive Committee. Santagati will be responsible for planning and organizing legal services and managing all business aspects. To Gregory A. Patterson of the *Boston Globe* the appointment marked a trend: "the nation's most prestigious law firms bringing in top executives to run their operations." . . . With the new title of executive vice-president—operations, **Jerry R. Davis,** S.M.'76, will head the consolidating of the Union Pacific railroad's two operating departments—the Union Pacific and Missouri Pacific. Chief engineer for the combined department is **Stanley K. McLaughlin,** S.M.'83. Meanwhile, **A. Anthony Chacon,** S.M.'85, has been appointed superintendent of the Union Pacific diesel locomotive shop, North Platte, Neb. Chacon joined Union Pacific in 1975, most recently serving as general mechanical engineer.

Armen Der Marderosian, S.M.'75, has been named vice-president and manager of the new Tactical Services Division of GTE Government Systems, a subsidary of the GTE Corp. The division will produce a military cellular telephone system for the U.S. Army. . . . **Neil Vander Dussen,** S.M.'70, has been named president and chief operating officer of the Sony Corp. of America, Park Ridge, N.J. Vander Dussen joined Sony in 1981 after 25 years of service with RCA. . . . **Thomas J. Vincent,** S.M.'68, formerly president and chief executive officer of Milchem, Inc., Houston, has been named president and chief operating officer of Borg-Warner Air Conditioning, Inc., York, Penn.

Rosemary A. Simmons, S.M.'84, has been promoted from director of strategic planning to vice-president—New England sales for NYNEX Business Information Systems Co., Boston.

Wayne J. Holman, Jr., S.M.'39, former treasurer, director and member of the executive committee of Johnson and Johnson, passed away on December 27, 1985. Holman's career at Johnson and Johnson spanned 32 years, ending with retirement in 1972; before joining the company he was an instructor in electrical engineering at Yale University. Holman served on the Board of Directors of the American Management Association; served for 12 years on M.I.T.'s advisory council and visiting committee of the School of Industrial Management; and was the first and founding president of the Society of Alfred P. Sloan Fellows of.

George "Skip" Page, S.M.'84, has been appointed finishing manager of the Boise Cascade Specialty Paperboard Division, Pressboard Products, at the Brattleboro, Vt., mill. Page joined Boise Cascade in 1984 as a business analyst in the Paperboard Division, and in his new position he will provide overall department management, production planning, and coordination of a quality assurance program. . . . **Milton A. Zimmerman,** S.M.'60, retired last June 30 as vice-president and assistant to the president at Campbell Soup Co., Camden, N.J., after 45 years of service with the firm.

Thomas J. Vincent, S.M.'68, has become president and chief operating officer of York International Corp., York, Pa., a new company formed by the spinoff from Borg-Warner of its Air Conditioning Group. . . . **David L. Chapman,** S.M.'70, is vice-chairman, president and chief executive officer of Cullinet Software, Inc., Westwood, Mass. Chapman formerly, served as senior vice-president for manufacturing at Data General Corp., Westboro, Mass. . . . **Robert B. Horton,** S.M.'71, formerly managing director of British Petroleum Corp., London, has returned to the U.S. as chairman, chief executive, and director of Standard Oil Co., Cleveland, Ohio. . . . **Thornton A. Wilson,** '53, has retired as chief executive officer but retains responsibilities as chairman and director of The Boeing Co., Seattle, Wash.

Senior Executives

Frank P. Silkman, '74, has changed jobs: from senior vice-president for world-wide field engineering to senior vice-president for manufacturing at Data General Corp., Westboro, Mass. . . . **Roger A. Moser,** '75, has been promoted from senior vice-president—research and development, to executive vice-president—operations for the Chemicals Group at the Ethyl Corp., Richmond, Va.

Lloyd E. Reuss, '71, is now executive vice-president for its North American car groups at General Motors, Detroit; he was formerly vice-president and group executive of Chevrolet-Pontiac and GM-Canada Group. With his new assignment comes a seat as director and member of GM's Executive Committee.

Management of Technology Program

The first Management of Technology Program reunion dinner was a great success! On June 6, the M.I.T. Museum put on a lovely cocktail reception and delicious dinner (especially the chocolate dessert!). Several faculty and staff from the Program came as well, forming a warm welcoming committee for returning members from each of the five past classes. The Sloan School's dean, **Abe Siegel,** had some special words of welcome for

Full Approval on Reactor Security

"It is our opinion that the security of the M.I.T. Research Reactor is satisfactory," reports a study team appointed by the Cambridge city manager at the request of the City Council.

"The structure and equipment are in excellent condition. . . . We found the physical security, access control, material storage, and fire suppression and safety to be satisfactory in both physical equipment and procedures."

The study team was appointed late last year after Cambridge neighbors expressed concern stimulated by an article in *Boston* magazine: many U.S. reactors provide inadequate security, especially against theft and illicit use of radioactive fuel, charged author Daniel Hirsch of the University of California at Santa Cruz.

Investigating the M.I.T. reactor were the city's director of emergency management, commissioner of health and hospitals, and fire and police chiefs.

They began their report by noting that, in contrast to power reactors, research reactors such as M.I.T.'s are designed to produce minimal amounts of heat. Hence they use small quantities of uranium and operate at temperatures well below the boiling point of water. Furthermore, in the M.I.T. design "the cooling water is fed into the reactor vessel from the top and removed from the top, and loss of coolant over the core could not result from breakage of coolant pipes," said the team's report.

On the other hand, the M.I.T. reactor is used nearly continuously and at moderate power levels, so levels of radioactivity are higher than in most research reactors. The result is that anyone attempting illicitly to remove uranium would be "either dead or seriously ill, unconscious, convulsing, bleeding internally and dying" before completing the task, said the study team.

Only 1.5 kilograms of uranium is kept in Cambridge in the form of unirradiated fuel elements for refueling. That's "substantially below . . . the absolute minimum needed to make a nuclear device using sophisticated technology and substantial economic resources," according to the study team report. □

the group, and the program director, **Ed Roberts,** '57, told some of his finest anecdotes and stories. Also there to welcome the graduates were Professors **Mel Horwitch, Russ Olive, Richard de Neufville** '60, (whose baby girl had been born just the night before), and **Ralph Katz,** as well as Jacalyn Walker-Sharp, program coordinator, and Jane Morse, program manager. Most of the spouses came as well.

We were delighted to see, from the inaugural class of '82, Barbara and **Elliot Blackman** and Joan and **Ken Miller.** The class of '83 was ably represented by Joyce and **Jim Tagliaferro. Erik Chaum,** Mary and **Bob Crook,** and Sharon and **Bruce Gobioff** returned for the class of '84, and Ruth and **Alan Drane, Gene Huang, John Kindinger, Anita Kirkpatrick** and her daughter, Roz, and **John Krawiec, Enrico Poggio** (alas, Pilar wasn't feeling well and couldn't attend), and **Sorab Vatcha** were there to represent the 1985 class. **Peter Drummond** called us from England to send his regrets. From the just-graduated class of '86 came Jan and **Dick Percoski,** Marge and **Rene Cormier,** Marlana and **Bill Culbert,** and Iris and **Grady Wheaton.**

In other news, **Charles Bow,** S.M.'84, writes that he and Alison moved to a new home in the Glasgow area on May 30, and they are expecting their first child in November. . . . **John Hallal,** S.M.'85, almost made it to reunion, but his plane from Phoenix didn't get in until 9:00 that evening. He had lunch over the reunion weekend with classmates **Enrico Poggio, Sorab Vatcha, Gene Huang, John Krawiec,** and **Jim Ishikawa.** John has been running the Avionics Facility for RCA's Automated Systems Division since his return last year and says things are going well (and are very busy!).

Richard Norton, S.M.'85, wrote us a newsy letter in May describing his new job in Orange, Calif., where he is assistant department head for PRC Engineering. He's working on several military projects as well as being responsible for design of improvements for the Los Angeles airport. He and his family are now living about five miles from **John Kindinger** and his family. Rich and Karen adopted their second child, Alexandra Devin Norton, in May. Both Alexandra and Samatha are doing well. . . . **Rick Orr,** S.M.'85, and Sallee called in May to let us know Ashley Crystal was born March 27 at seven pounds, five-and-one-half ounces. Rick said he misses Utah. The Orrs moved to Arlington, Tex., this year for Rick's new job as manager for cost reduction at LTV Aerospace and Defense, Dallas. . . . **Drew Peck,** S.M.'85, stopped by in May for a chat. He says Liz misses Boston!—Jane Morse, Program Manager, Management of Technology Program, M.I.T., Rm. E52-125, Cambridge, MA 02139

XVI AERONAUTICS AND ASTRONAUTICS

Holt Ashley, Sc.D.'51, professor of aeronautics, astronautics and mechanical engineering at Stanford, has been elected to fellow grade in the American Society of Mechanical Engineers. Ashley joined Stanford in 1967, and he is honored by ASME for his expertise in aerodynamics, aeroelasticity, and flight-vehicle engineering. . . . **Arthur E. Wennerstrom,** S.M.'58, chief, Compressor Research Group at Aero Propulsion Laboratory, Wright-Patterson Air Force Base, Ohio, has served on the 1985-86 National Nominating Committee of the American Society of Mechanical Engineers.

Stephen L. Finberg, '77, senior electrical engineer at the Charles Stark Draper Laboratory, Cambridge, is a member of the *Daedalus* Working Group, responsible for analogue and digital circuit design for the human-powered aircraft scheduled to attempt a flight from Crete to Greece as early as a year from now. . . . **Albert F.W. Parr,** S.M.'51, reports, "Retired from the optical subsidiary of Farrand Industries, where I served in various capacities from chief project engineer to military marketing manager. Returned to Norden Systems Division of United Technologies as senior systems engineer after 25 years of absence, then left Norden as Systems Department head after the company moved from White Plains, N.Y., to Norwalk, Connecticut."

XVII POLITICAL SCIENCE

Preparing for its June 23, 1986, cover story on "star wars," *Time* assembled a group of experts to discuss issues and advise the editors. Among them: Lt. General **James Abrahamson,** '55, director of the SDI Organization in the Department of Defense; Professor **Stephen Meyer** of M.I.T., an expert on Soviet defense and arms control; Professor **Ashton Carter** of Harvard's Kennedy School of Government, who did postdoctoral work on arms control at M.I.T. in 1979-81; and Professor **Jack Ruina,** director of the Arms Control and Defense Studies Program in the M.I.T. Center for International Studies.

XVIII MATHEMATICS

Professor **Frank Morgan,** '74, of M.I.T. is the author of "Soap Films and Problems Without Unique Solutions" in *American Scientist* for May/June 1986. "It may at first seem paradoxical," writes Morgan, "that a mathematical problem can have many solutions." But it can, he says, and he cites for evidence his studies of multidimensional soap films creating a variety of area-minimizing surfaces.

Assistant Professor **Lloyd N. Trefethen** in the department at M.I.T. was picked late last spring by the National Science Foundation for a Presidential Young Investigator Award. He'll use the funds, which are designed to encourage promising young faculty to develop their teaching/research careers, for research in applied mathematics.

Felix Haas, Ph.D.'52, of Purdue University, has stepped down from his post of executive vice-president and provost and was appointed (last July 1) to the newly created Arthur G. Hansen Distinguished Professorship of Mathematics. . . . "A man I admire very deeply," said Purdue's president, Steven C. Beering.

Douglas B. West, Ph.D.'78, has been promoted to tenure in the Department of Mathematics at the University of Illinois, Urbana. . . . **M. Ram Murty,** Ph.D.'80, is presently associate professor of mathematics at McGill University, Montreal.

M. J. Draper

XX APPLIED BIOLOGICAL SCIENCES

To Professor **Marcus Karel,** Ph.D.'60, of M.I.T., the Nicholas Appert Award of the Institute of Food Technologists for "preeminence in and contributions to the field of food technology." Karel was cited for work in freeze drying and for studies of quality changes in food.

Marta J. Draper, Ph.D.'20, has been appointed director of research and development, international, for the Campbell Institute for Research and Technology, the research and development division of Campbell Soup Co., Camden, N.J. Draper previously held several research and development positions with Nabisco Brands, most recently as director of product concept development.

TECHNOLOGY AND POLICY PROGRAM

Dwayne S. Breger, S.M.'83, is now working in Washington, D.C., with a consultant on solar energy systems. . . . **Jim Durand,** S.M.'78, is currently at the University of Missouri as a visiting professor, having completed a Ph.D. in mechanical engineering at the University of Missouri (Columbia) in the summer of 1985. . . . **Kevin Fitzgerald,** S.M.'86, is working in Washington, D.C., in the Renewable Resource Division of the Energy Department.

S. Krishnamurthy Sarvadevabhatla, S.M.'80, has moved from India to join Booz-Allen Hamilton in Maryland, working on strategic consulting for electric utilities.

Frank Scibilia, S.M.'86, is working in the Telecommunications Section of A.D. Little, Inc., Cambridge.—Richard de Neufville, Chairman, Technology and Policy Program, M.I.T., Rm. 1-138, Cambridge, MA 02139

E. Kuh

J. T. Rule II

F. H. Conant

Edwin Kuh, 1925-1986: Innovator in Econometric Modelling

Edwin Kuh, professor of economics and finance at M.I.T. and who was a pioneer in computer-based econometric studies, died of cancer on June 9 at his home in Cambridge. He was 61.

Professor Kuh, who held joint appointments in the Sloan School of Management and Department of Economics, was an authority on econometric models and their use and reliability in forecasting such functions as production, savings, investment, business cycles and unemployment. He had served as director of M.I.T.'s Center for Computational Research in Economics and Management Science since its establishment in 1978.

Professor Kuh was the first economist to point out the variations in the productivity of the economy at various stages of the business cycle. He observed that productivity improved sharply during the recovery phase of the business cycle, peaked before the economy itself peaked, and declined just before the economy slid into recession.

Dean Abraham J. Siegel of the Sloan School described Professor Kuh as "one of the outstanding pioneers in econometric studies. His work combined theoretical and empirical considerations in the best tradition of high-quality econometric research."

Professor Peter A. Diamond, head of the Department of Economics, said Kuh's recent work on the robustness of econometric estimates was "an important part of the development of this exciting area."

Other tributes came from Harvard economics professor John R. Meyer, who called Kuh "a consummate, classic academician who sought truth for its own sake"; and John Kenneth Galbraith, professor emeritus of economics at Harvard, who described Professor Kuh as "one of the most innovative economists of his generation."

Professor Kuh received a B.A. degree at Williams College in 1949 and the Ph.D. from Harvard in 1955. He began his teaching career as a lecturer at Johns Hopkins University and was appointed to the M.I.T. faculty in 1955 as an assistant professor at the Sloan School; Kuh rose to become professor of finance and of economics in 1962.

In 1963-64 Kuh was on leave from M.I.T. to be acting principal investigator for the joint econometric model project of the Brookings Institution and the Social Science Research Council. He had been a member of the President's Materials Policy Commission and the Economic Advisory Panel of the U.S. Postal Service, and he had been a consultant to the General Accounting Office. He was also an advisor to the governments of Greece, China and Costa Rica. The econometric systems he developed were widely used in Europe by major banks and research organizations.

Professor Kuh was active in politics, serving as an advisor to Robert F. Kennedy in his 1968 presidential bid and to George S. McGovern in the 1972 presidential campaign. Professor Galbraith noted Kuh's concern for broad human issues, including efforts to support minorities and women and to end the war in Vietnam.

John T. Rule II, 1900-1986

Professor Emeritus John T. Rule II, '21, former dean of students and head of the courses in General Science and General Engineering, died in Elkart, Kan., on May 24. He was 85.

In 30 years at M.I.T., Rule had active roles in teaching and administration.

After three years teaching engineering drawing in the Department of Mechanical Engineering, Rule became head of the Graphics Section in 1939. A decade later he became head of the courses in General Science and General Engineering, and he was Dean of Students from 1956 to 1961. He was also chairman of the M.I.T. Student-Faculty Committee for two years and a member of the Undergraduate Policy Committee for four years.

Rule was co-author of two books, *Descriptive Geometry* (1946) and *Engineering Graphics* (1948), and in 1946 he was chairman of the Engineering Drawing Division of the American Society for Engineering Education.

Professor Rule worked on three-dimensional photography with Edwin Land, and he created the first 3-D movie for the 1941 World's Fair. He also pioneered the development of analytical graphics and teamed with his colleague Professor Stephen A. Coons in research on graphic representation.

During World War II Rule was in charge of the development of the Mark I machine gun trainer for the U.S. Navy, using stereoscopic techniques to simulate combat conditions encountered in aerial warfare.

Rule's undergraduate degree was in business and engineering administration. He did graduate work at Harvard University in 1921-22, then worked as an industrial engineer at Curtiss Aircraft.

Frank H. Conant, 1907-1986

Frank H. Conant of Mashpee, who originated and then for 45 years directed Graphic Arts Services at M.I.T., died May 25 at the Falmouth Nursing Home after a long illness. He was 79.

Conant was farming in New Hampshire in 1926 when his brother, Russell W. Conant, '23, persuaded Frank to take a job at M.I.T. processing photographs for a research team working on a color film project. That was the beginning of a career that culminated with Conant directing a department providing drafting, photography, offset printing, and public address/projection services.

Robert A. Lovett, 1896-1986

Robert A. Lovett, an international financier who was Life Member Emeritus of the Corporation, died May 7 at the age of 90. Mr. Lovett, who was associated with Brown Brothers Harriman for more than 60 years, had been a member of the Corporation since 1955.

Mr. Lovett also had a distinguished

PHOTOS: M.I.T. MUSEUM

public career, beginning in 1940 as special assistant to the secretary of war. By 1941 he was assistant secretary of war for air, a post in which he oversaw preparations for implementing the Marshall Plan.

In 1950 he was named deputy secretary of defense, following which he served as secretary of defense from 1951-53. He also served as an advisor to Presidents Eisenhower and Kennedy and was a leader of the U.S. Arms Control and Disarmament Agency.

"M.I.T. has lost a loyal friend and counselor whose participation in the work of the governing body will be remembered with pride and appreciation," Corporation Chairman David Saxon, '41, said in a letter informing the Corporation of Mr. Lovett's death.

Deceased

The following deaths have been reported to the Alumni Association since the *Review*'s last deadline:

Stanley H. Lawton, '11; May 19, 1986; Cambridge, Mass.
Allen F. Brewer, '13; April 3, 1986.
Barnett D. Gordon, '16; May 14, 1986; Chestnut Hill, Mass.
Henry B. Shepard, '16; May 14, 1986; West Newton, Mass.
Abraham J. Williams, '19; March 24, 1986; Tegucigalpa DC, Honduras.
Henry W. Hills, '20; April 22, 1986; Melrose, Mass.
Carleton T. Proctor, '20; January 19, 1986; Reading, Mass.
Edmund G. Farrand, '21; May 1986; Del Mar, Calif.
Robert L. Moore, '21; April 23, 1986; Concord, Mass.
John T. Rule, '21; May 24, 1986; Elkart, Kans.
Howard B. Upham, '22; May 29, 1986; Cashiers, N.C.
Mason D. Harris, '23; March 29, 1986; Fitchburg, Mass.
Ernesto B. Ledesma, Sr., '23; 1986; Belair Makati, Philippines.
James A. Pennypacker, '23; April 7, 1986; Clearwater, Fla.
Thomas L. Powers, '23; March 28, 1986; Fargo, N.D.
J(ohn) Theodore Acker, '24; November 3, 1985; Bethlehem, Penn.
Elmer W. Brugmann, '24; May 22, 1986; Wilmington, Del.
Ernest L. Kallander, '24; April 18, 1986; Southborough, Mass.
Charles A. Dyson, '25; May 26, 1985; New Rochelle, N.Y.
Benjamin A. Oxnard, '25; June 9, 1986; Atlanta, Ga.
Harry B. Smith, '25; July 13, 1985; Winthrop, Mass.
Alexander E. Ulmann, '25; April 23, 1986; Long Island, N.Y.
Henry W. Newell, '27; February 13, 1986; Muscatine, Iowa.
Howard W. Page, '27; April 21, 1986; Mamaroneck, N.Y.
Carl H. Wies, '27; April 22, 1986; New London, Conn.
Frank L. Wattendorf, '28; June 12, 1986; Washington, D.C.
Arthur A. Jones, '29; December 3, 1985; New Bedford, Mass.
Carl F. Norbeck, '29; September 21, 1985; New Haven, Conn.
Arnold S. Wood, '29; April 14, 1986; Osprey, Fla.
Joseph Harrington, Jr., '30; June 13, 1986; Waltham, Mass.
Bror J. Grondal, '31; May 17, 1986; Center Ossipee, N.H.
David L. Babcock, '33; January 22, 1986; Rochester, N.Y.
Lennox H. Lindsay, Jr., '33; January 31, 1986; Laramie, Wy.
Preben Oldenburg, '33; March 29, 1986; Grass Valley, Calif.
Fred C. Walker, '33; July 17, 1984; Albuquerque, N.M.
W. Leslie Doten, Jr., '34; March 16, 1986; Silver Lake, N.H.
E. Gordon Riley, '36; March 18, 1986; Severna Park, Md.
Albert K. Showalter, '36; March 15, 1986; Georgetown, Del.
Russell C. Buehl, '37; June 1, 1986; Sarasota, Fla.
Lyle C. Jenness, '37; May 4, 1986; Orono, Maine.
Eric O. Moorehead, '37; May 28, 1986; Sonoma, Calif.
John P. Glass, Jr., '38; December 16, 1985; Essington, Penn.
Arthur F. Gould, '38; June 21, 1985; Bethlehem, Penn.
Lawrence F. Cavendish, '39; March 16, 1986; Harwichport, Mass.
Herman Bartholomay, '40; April 3, 1986; Scottsdale, Ariz.
Tirso G. Fajardo, '41; May 6, 1986; New York, N.Y.
Richard E. Russell, '42; April 16, 1986; Ann Arbor, Mich.
Herbert Greenwald, Jr., '43; December 2, 1985; Columbus, Ohio.
Gerome Gordon, '46; August 1985; Johns Island, S.C.
Neil M. Blair, '47; April 3, 1986; Richmond, Va.
Morton V. Lewis, '47; March 1986; Englewood, N.J.
Harold Ytredal, '47; April 7, 1986; Seattle, Wash.
William S. Spiller, '48; 1986; King of Prussia, Penn.
Arthur R. Teager, '48; May 22, 1986; Somerset, N.J.
Rex G. Fluharty, '49; April 26, 1985; Los Alamos, N.M.
Roy W. Jenkins, '50; May 3, 1986; Kerrville, Tex.
Mark R. Thomson, '51; October 4, 1985; Winter Park, Fla.
Frederick E. Jellow, '53; February 1986; Lompoc, Calif.
Clive Eustace, '58; March 1983; West Hartford, Conn.
Richard E. Price, '63; March 30. 1986; Lafayette, Calif.
Jeanne L.H. Fertel, '64; 1986; Honolulu, Hawaii.
Richard T. Murray, '64; January 26, 1986; Somerville, Mass.
Peter Bergen, '66; June 17, 1983; Ottawa, Canada.
Michael A. Pagano, '70; May 10, 1986; Westfield, N.Y.
Robert T. Gschwind, '75; April 29, 1986; Churchville, Md.
Dale T. Caddy, '79; April 15, 1983; Bridgeport, Ill.
Peter T. Reid, '88; May 15, 1986; St John, Canada.

ALLAN J. GOTTLIEB

Celtics vs. Lakers: Was It *Really* Amazing?

In the last issue we announced that David Meyer was the winner of the $100 prize for the best solution to **JAN. 2**. As you may recall, Philip Hogin proposed the problem, offered the prize, and judged the solutions, and I had promised to publish the winning solution. I have now received the solutions from Mr. Hogin, and unfortunately, as might be expected, neither the problem nor the solution was trivial and Mr. Meyer's response is rather lengthy. So instead of publishing it, I will instead mail a photocopy of Hogin's solution to any reader who wants it. Please refer to the problem as **1985 JAN 2**. In the "Better Late Than Never" section of this issue, I include an excerpt of Mr. Hogin's letter to Mr. Meyer that, in very general terms, comments on the winning solution.

Problems

A/S 1. We begin with a computer-related problem from Walter Nissen, who wants to know what is particularly interesting about the factors of the following numbers: 1271, 42477, 74989, 128929, 923521, 4424351, 4782969, 536215711, 2889101203, 98695877281, 424777960767, 1470848491213, 7532627125087, 7617609926757, 12893722612807, 17037029794091, 28917102427847, 170396299851737, 1703971665820979.

A/S 2. Nob Yoshigahara asks another problem concerning factoring, one which first appeared in the Japanese Journal *Quark*:

Find the smallest positive number whose prime factorization consists of the nine digits 1 through 9 and then find the smallest positive number whose prime factorization consists of the ten digits 0 through 9. To clarify this question, we note that 2×13 would be the answer for the three digits 1 through 3.

A/S 3. The following problem is from Phelps Meaker:
Cooking vegetables such as potatoes is carried on more rapidly as the amount of exposed surface is increased. Take a very large potato and trim it to a 2" cube. Divide it into 8 slices with 7 equally spaced cuts. Find the ratio of exposed surface area to number of cuts. Now make 7 cuts in another plane, resulting in 64 little sticks, as for French fries. Again, find the ratio of total area to total number of cuts. Again make 7 cuts, resulting in 512 tiny cubes. The ratios all have similar repeating decimals. Do you dare make another series of cuts into the fourth dimension?

A/S 4. A basketball problem from David DeLeeuw:
During the fifth game of last year's basketball championship series between the Boston Celtics and the Los Angeles Lakers, the television commentators constantly reminded the viewing audience that 10 of the last 15 winners of game number 5 of the championship series went on to become the eventual world champions. Determine whether this is really such an "amazing" statistic as the announcers would have us believe. Stated differently, given two evenly matched teams participating in a best-four-out-of-seven series, what is the probability that the team that wins the fifth game of the series will win the series?

A/S 5. We close this section with a geometry problem from Dennis White:
A "right tetrahedron" has a vertex with three right angles. If in a right tetrahedron, A,B,C denote the areas of the three faces that share the "right vertex" and D denotes the area of the face opposite the right vertex, show that $A^2 + B^2 + C^2 = D^2$ (a "Pythagorean Theorem" for areas in 3-space).

Speed Department

SD 1. Jim Landau wants to know the

SEND PROBLEMS, SOLUTIONS, AND COMMENTS TO ALLAN J. GOTTLIEB, '67, THE COURANT INSTITUTE, NEW YORK UNIVERSITY, 251 MERCER ST., NEW YORK, N.Y. 10012.

value of i^i, where i is the principal square root of -1.

SD 2. Our final problem for this issue is from *The Tech*:
Give the next number in the sequences:
a) 11, 13, 17, 25, 32, 37, 47, 58, 71, . . .
b) 7, 3, 10, 4, . . .

Solutions

APR 1. Develop a computer program that determines the day-of-the-week for any Nth day after a selected date.

Only the proposer, Harry Zaremba, sent us a computer-oriented solution; his BASIC program appears below, followed by a nomogram that Walter Cluett attributes to the late Professor Douglas P. Adams of M.I.T. in the 1960's:

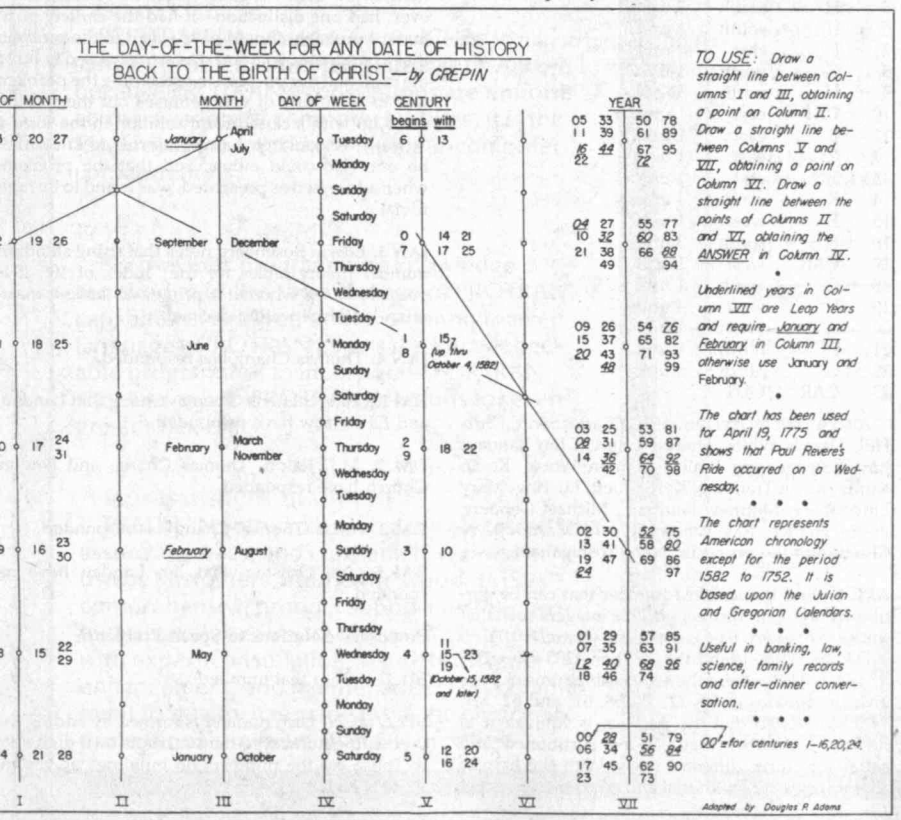
The program listed below is in BASIC language for a hand-held Sharp scientific computer, Model EL-5500II. The numeric function INT determines the integer portion of a numerical value. Input data consists of numerical values for the year, month, and day of the preselected date and for the number of days N for which the date and day-of-week is desired. Leap years are accounted for in the program.

```
10 CLEAR: PRINT = LPRINT
20 DIM MOS(12), Y(2), M(2), F(2), DWS(6)
30 FOR I = O TO 6: READ DWS(I)
40 DATA "SATURDAY," "SUNDAY," "MON-
DAY," "TUESDAY"
50 DATA "WEDNESDAY," "THURSDAY," "FRI-
DAY": NEXT I
60 FOR J = 1 TO 12: READ MOS(J)
70 DATA "JAN.," "FEB.," "MAR.," "APR."
80 DATA "MAY," "JUNE," "JULY," "AUG."
90 DATA "SEPT.," "OCT.," "NOV.," "DEC.":
NEXT J
100 INPUT "YEAR = ?"; "MONTH = ?"; M
110 INPUT "DAY = ?"; D, "NO. OF DAYS = ?";
N
120 M(1) = M: Y(1) = Y: K = 2
130 GOSUB 350
140 DF = DM - D
150 IF N > DF THEN 170
160 DA = N + D: GOTO 240
170 S = DF
180 M(1) = M(2): Y(1) = Y(2): K = 2
190 GOSUB 350
200 S = S + DM
210 T = N - S
220 IF T > 0 THEN 180
230 DA = DM + T
240 J = 1
250 IF M(1) = J THEN 270
260 J = J + 1: GOTO 250
270 PRINT MOS(J); DA; ""; Y(1)
280 D1 = DA: K = 1
290 GOSUB 390
300 DW = F(1) - INT(F(1)/7)*7
310 J = 0
320 IF DW = J THEN 340
330 J = J + 1: GOTO 320
340 PRINT DWS(J): GOTO 100
350 D1 = 1
360 IF M(1) < 12 THEN 380
370 M(2) = 1: Y(2) = Y(1) + 1: GOTO 390
380 M(2) = M(1) + 1: Y(2) = Y(1)
390 FOR I = 1 TO K
400 A = 365* Y(I) + D1 + 31*(M(I) - 1)
410 IF M(I) > 3 THEN 440
420 B = INT(Y(I)/4) - INT(.4*M(I) + 2.3) - INT(3/
4*INT(Y(I)/100 + 1))
430 F(I) = A + B: NEXT I: GOTO 460
440 B = INT((Y(I) - 1)/4) - INT(3/4*INT((Y(I) - 1)/
100 + 1))
450 F(I) = A + B: NEXT I
460 DM = F(2) - F(1): RETURN
```

The subroutine from lines 350 to 460, inclusive, determines the number of days DM in a particular month, and the subroutine from lines 390 to 460 is used to determine F(1) for use in calculating the number DW that corresponds to the number of the required day-of-the-week.

APR 2. In the family of functions $f_n(x) = \int_{t=0}^{x} \sin(t^n)dt$
the infant f_1 is reasonably well behaved; it is bounded and oscillates between -1 and $+1$. How well behaved are the other family members, f_2, f_3, etc?

Matthew Fountain sent us the following solution: The infant f_1 oscillates between 0 and 2. It is $\sin(t^n)$ that oscillates between -1 and $+1$. Hereafter assuming $n>1$, $\sin(t^n)$ oscillates between -1 and $+1$ with a frequency that increases with t. The value of



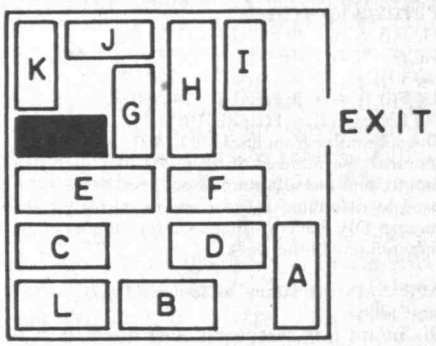
f_n is always positive, reaching its maximum at $x = \pi^{1/n}$. This maximum is 2 when n = 1 and decreases as n increases. As x increases from 0, f_n alternately increases and decreases with increasing frequency. Each successive increase or decrease is less than its preceding decrease or increase, so that at large x, f_n approaches a constant value.

APR 3. Arrange the digits 1 through 9 into two proper fractions and two positive integers so that the four numbers total 100. The result of interchanging digits in the integers is not considered a different arrangement—e.g., 1/8, 63/72, 95, and 4 is considered the same as our original arrangement.

I must apologize for an error that I (personally) introduced into this problem. Mr. Duffy did not require that there be exactly *two* positive integers, and hence the seven solution sets include:
6/7 4/28 95 3 1.
Steve Feldman found the six solutions to the problem as printed:
1/2 38/76 4 95
1/3 56/84 2 97
2/7 45/63 1 98
3/6 27/54 1 98
3/7 16/28 4 95
3/6 9/18 74 25

Also solved by Dennis White, Jim Landau, Jim Rutledge, Matthew Fountain, Michael Gennert, Ray Kinsley, and the proposer, Emmet Duffy.

APR 4. List the shortest sequence of moves necessary to free the black car in the overcrowded parking lot. Cars can move only back and forth and cannot turn.



The following 23-move solution is from Darryl Ephraim:

1	A	north	3 units
2	F	east	1 unit
3	D	east	1 unit
4	B	east	2 units
5	H	south	3 units
6	I	south	1 unit
7	J	east	3 units
8	G	north	1 unit
9	H	north	3 units
10	CAR	east	1 unit
11	E	east	1 unit
12	C	east	1 unit
13	L	east	1 unit
14	K	south	4 units
15	E	west	1 unit
16	H	south	3 units
17	CAR	west	1 unit
18	G	south	1 unit
19	J	west	4 units
20	A	north	1 unit
21	I	north	1 unit
22	G	north	1 unit
23	CAR	OUT	

Also solved by Avi Ornstein, Charles Swift, Chris Hill, Dennis White, Dudley Church, Jim Landau, Jim Rutledge, Jim Walker, Jordan Wouk, K. D. Kuntz, Kevin Trammel, Kyre Cluett, Lu Ting, Mary Lindenberg, Matthew Fountain, Michael Gennert, Pierre Heftler, Ray Kinsley,Ronald Martin, Kyre Cluett, and the proposer, Nob. Yoshigahara.

APR 5. Find the smallest number that can be partitioned into four distinct positive integers such that the sum of every pair is a perfect square.

Dennis White found the solution 4205 = 2 + 359 + 482 + 3362, where the six possible sums of pairs give the squares of 19, 22, 29, 58, 61, and 62. Mr. White observed that the problem is equivalent to finding a number that can be partitioned into squares in three different ways. With the help of algebra combined with trial and error, he set up and solved a set of second-order equations involving several variables. Although not too hard to follow, the solution would be hard to typeset and hence I will instead mail copies to anyone who sends a request.

Also solved by George Thomas, George Welti, Matthew Fountain, and the proposer, P.V. Heftler.

Better Late Than Never

1985 OCT 3. John Langhaar notes that the solution given is clearly wrong if the relevant points are colinear. In that case the median and not the mean gives the correct answer. For the two-dimensional case he gives an example to show that neither the median nor the mean is correct. The problem is still open.

OCT 5. Mary Lindenberg has responded.

N/D 1. Jim Landau tightened up his (published) proof by showing that the constructed point D satisfies the necessary properties. Frank Rubin and Dennis White noticed that the "human-friendly version" given is not correct. Thomas Weiss has also responded.

N/D 3. Dennis White believes that the problem still holds if complex numbers are permitted, but not using the proof given. John Prussing found a simpler solution.

N/D 4. Thomas Weiss has responded.

JAN 1 1986. Thomas Chang has responded.

JAN 2. As mentioned in my introductory remarks above, what follows is a portion of the letter that Philip Hogin sent to David Meyer:
You will be interested to know that I received 31 responses (somewhat more than the norm—Ed.). Almost all began by pointing out, as you did, that the practical solution was a rather simple pair of parametric equations relating x and y to alpha. About half of the rest then proceeded, as you did, to attempt a nonparametric solution, concluding with some formidable approximation with the potential of a very small error. As stated in the problem, an approximate solution was acceptable, so there were many eligible solutions. Yours, however, had one distinction—it had the earliest postmark. I probably should have stated in the problem that a parametric solution was actually used to build the cam, and our purpose in presenting the problem was to see if any of you geniuses out there could come up with a closed-form solution in the form y = f(α)—we couldn't. I am comforted to know that no one else could either, and that the problem, when addressed as presented, was found to be nontrivial.

JAN 3. Edwin Rosenberg notes that using standard number theory tables for the "index of 10" it is possible to tell whether a prime will have a maximum-length repeating decimal.

JAN 4. Thomas Chang has responded.

F/M 1. Lester Steffens, Thomas Chang, Jim Landau, and Eli Passow have responded.

F/M 2. M.J. Ralph, Thomas Chang, and Dudley Church have responded.

F/M 3, F/M 4. Thomas Chang has responded.

F/M 5. Avi Ornstein and Jim Landau have responded.

Proposers' Solutions to Speed Problems

SD 1. $e^{-\pi/2}$, a real number!

SD 2. (a) 79. Each number is formed by adding the preceeding number to the sum of its own digits. (b) 8. These are the numbers on buildings on the infinite corridor. □

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Looking Behind the Factory Gates

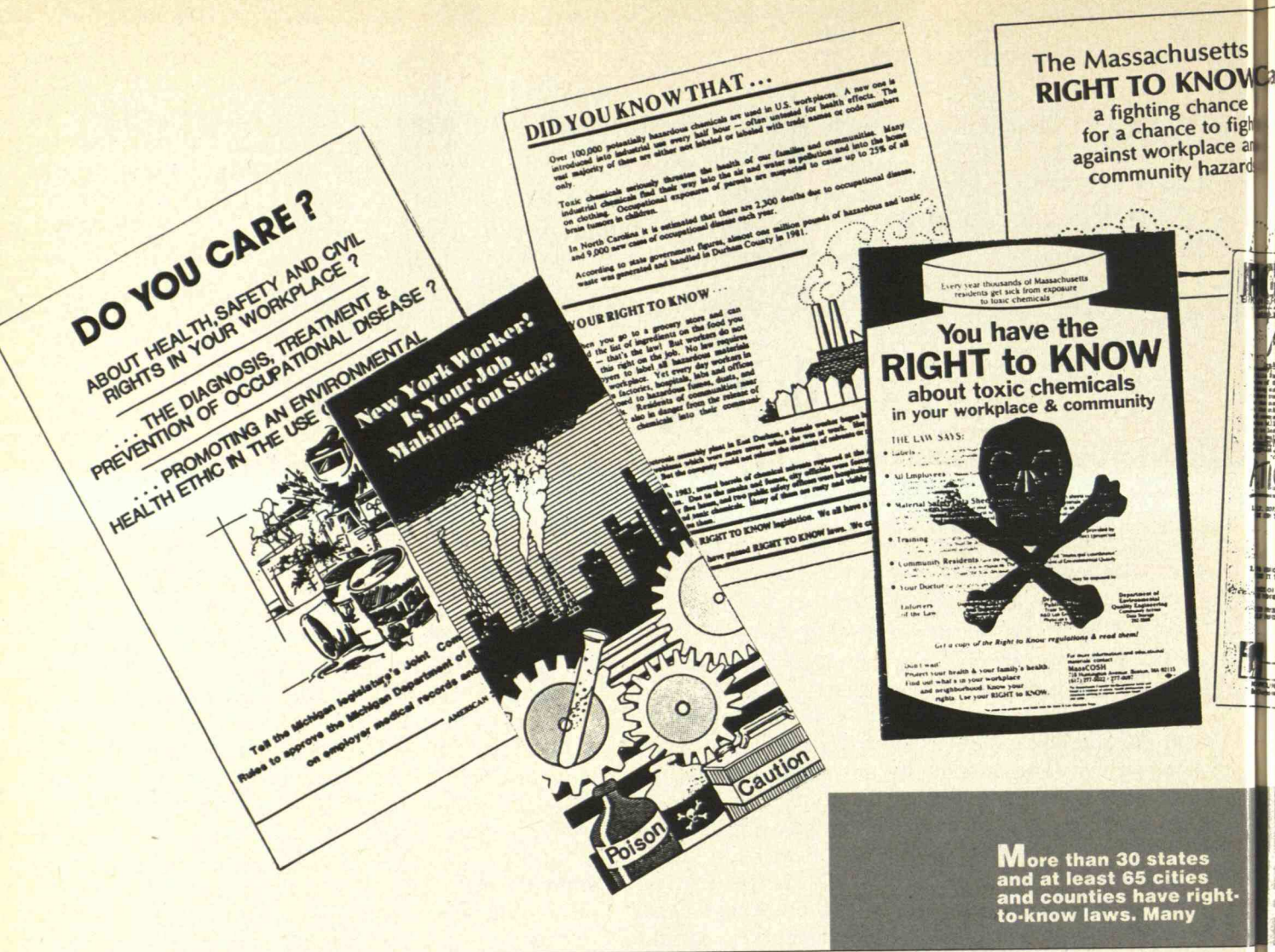
BY CARON CHESS

Bill Kane of the United Auto Workers interrupted his testimony to hoist two ominous red cylinders labeled X19 and K9 to the witness table, point them at members of the Philadelphia City Council, and turn the valves. The hissing of gas filled the council chamber. In response to council members' alarmed questions, Kane calmly echoed the words he said workers had heard too many times: "Don't worry. It won't hurt you." The cylinders contained only carbon-dioxide gas. But Kane had made his point: workers should have a right to know about the chemicals they handle.

More than 50 people joined Kane that day to testify in favor of a bill to require local businesses to disclose the names of the chemicals at their facilities. Bob Kumosinski, a member of the Bridesburg Pollution Patrol, a neighborhood watchdog group, expressed frustration. Although he lives in an industrialized neighborhood with a cancer-death rate nearly double the national average, he did not know what is released into the air outside his home. John Reilly, then president of the Firefighters Association, spoke of his members' need to know what chemicals they might encounter in a fire. Mark Sey, a pediatrician for an industrialized area of Philadelphia, told of his difficulty finding out the name of a substance in which children had been found playing.

Business opponents of the proposal took the stand the next day to argue that a right-to-know law would be hazardous to the economic health of the corporate community. The Chamber of Commerce said that such legislation would force businesses to divulge confidential business information, ultimately costing the city jobs: industry would leave for less restrictive areas. W. Thacher Longstreth, then president of the chamber, also remarked that "a little knowledge can be a dangerous thing," voicing industry fears about revealing information to the public. Finally, opponents contended that toxics information was readily available and that the bill merely duplicated existing law.

PHOTOS: LAURA DREY; RICK GOODWIN



More than 30 states and at least 65 cities and counties have right-to-know laws. Many

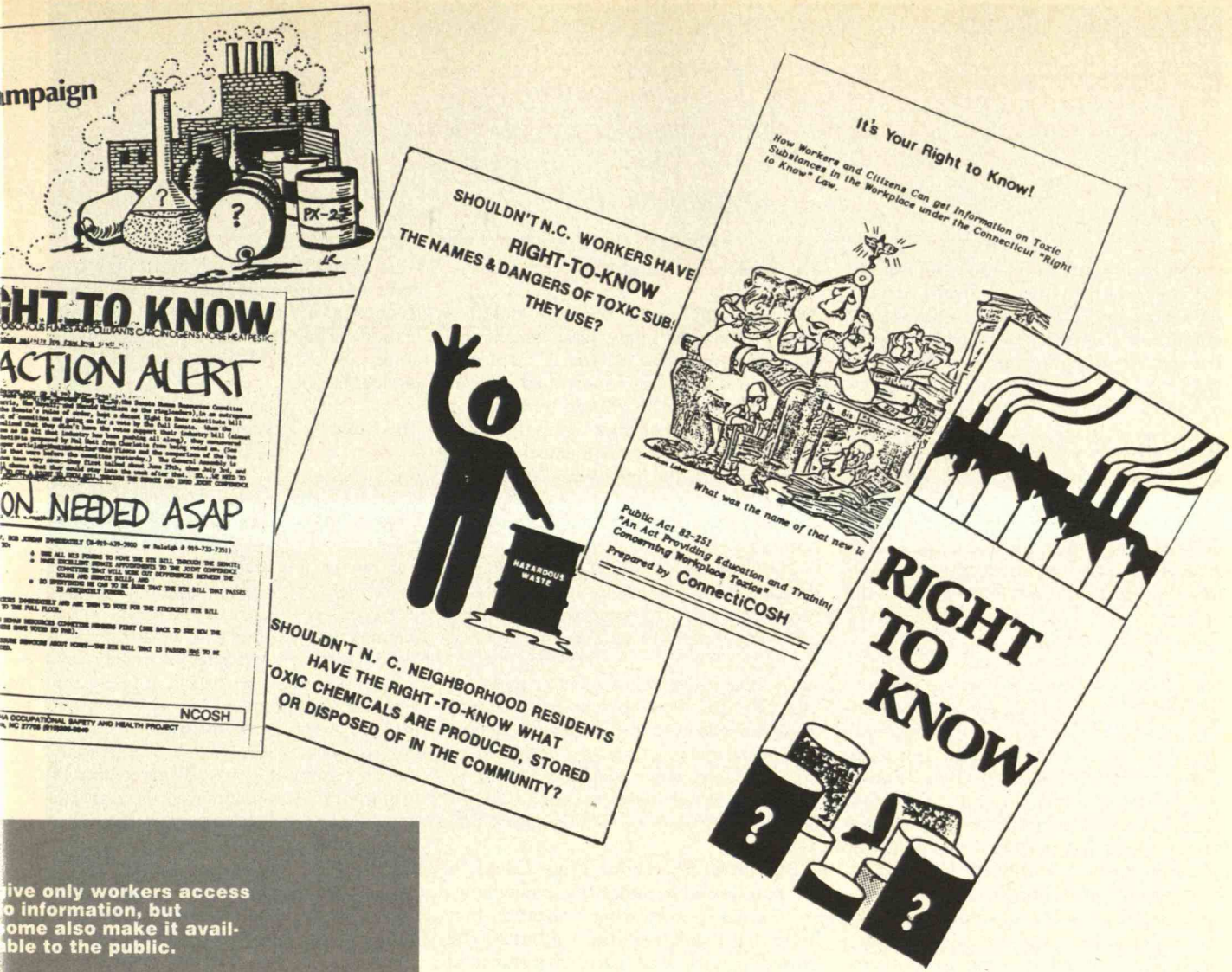
A coalition of more than 40 community, environmental and labor groups countered industry's lobbying with a highly visible campaign to win right-to-know legislation: unifying labor and environmental groups, holding high-profile events, and organizing at a grass-roots level to put pressure on key elected officials. When the city administration proposed what the coalition dubbed a "know-nothing" version of the bill, the coalition demonstrated outside then mayor William Green's office with a huge report card that gave him flunking grades in a number of subjects, including public health.

After months of controversy, in 1980 the Philadelphia City Council approved the first law in the country giving both workers and community residents the right to know the names of substances found in city businesses. Five states had previously enacted right-to-know legislation granting only workers access to such information.

The passage of Philadelphia's law encouraged many environmental and labor groups to push for similar legislation. These groups hoped that legislation would take the lid off what they saw as unhealthy secrecy on the part of industry. Currently, more than 30 states and at least 65 cities and counties have some form of right-to-know legislation. Many of the state laws give only workers access to data. A more limited number, including those of Maryland, Massachusetts, New Jersey, and Pennsylvania, make information available to the public. A new generation of right-to-know laws, enacted in the wake of the Bhopal disaster, is oriented toward providing information and developing programs to plan responses to emergency situations. In fact, some states, such as Illinois and California, that already had worker right-to-know laws on the books recently added statutes to deal with emergency-response issues.

The laws vary in other respects. The list of chemicals covered, the types of businesses that are required to comply, the provisions regarding labeling of containers, and the stringency of enforcement provisions all affect the ability of a right-to-know law to protect public health. For example, former proponents of a right-to-know act for Louisiana found the law so weak and unlikely to improve public health that they dubbed it the first "right-to-conceal" law, says the *Right-to-Know News*, a trade publication. A federal regulation issued by the Occupational Safety and Health Administration (OSHA) also grants workers access to information, but this regulation was challenged in court by states that had their own right-to-know laws and by advocates of those laws. They were concerned that the federal regulation had some major flaws that limited worker protection and also threatened to undermine laws passed at the state and local levels.

CARON CHESS had a central role in coordinating the campaign for Philadelphia's right-to-know legislation. She was right-to-know coordinator for the New Jersey Department of Environmental Protection (DEP). This article does not necessarily reflect the views of DEP.



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The New Jersey Model

The difference between a law that sits on the shelf and one that has the potential to reduce exposure to toxic chemicals depends on a number of factors, particularly the strength of the legislative provisions. New Jersey's legislation, signed by Republican Governor Thomas Kean in 1983 with a strong statement of commitment, is still considered a model by those drafting similar legislation.

The Department of Environmental Protection (DEP) administers the environmental provisions of the law and the Department of Health (DOH) administers the occupational provisions of the law. These two departments have the statutory authority to collect information sufficiently detailed to develop chemical profiles of specific industries and statewide data summaries, such as a listing of all locations where a specific chemical is found. Both types of analyses are vital to understanding the state's toxics problems. The agencies have developed extensive lists of chemicals that form the basis for companies to report substances at their facilities, label their containers, and train workers concerning hazards. The lists, which the agencies intend to expand, presently include more than 2,000 substances that have the potential to adversely affect health or the environment. Many of the substances are of particular concern to emergency-response personnel.

In order to simplify tracking toxics in the state, DEP developed a comprehensive one-page survey form on which a company is required to report the substances it uses, manufactures, or releases. On the one page, the company also reports the percentage of the substances included in a product and the maximum quantities of substances on site at any point during the year. By contrast, most right-to-know laws do not require employers to divulge their inventory quantities, thus limiting evaluation of potential hazards. For example, fire fighters will respond differently to an emergency involving 10,000 pounds of an explosive rather than 10 pounds.

The New Jersey statute is also one of the few that requires selected companies to report detailed information about disposal practices and discharges into the environment. This type of information is essential for developing a complete picture of a facility and for tracking the fate of chemical substances. DEP reviews preliminary survey forms and selects employers whose activities warrant such detailed reporting. This limits the number of employers who must comply with extensive reporting requirements.

A great many right-to-know statutes do not require employers to complete uniform surveys. Instead, these statutes rely on businesses to maintain files or to submit several pages of health-and-safety information for each chemical they handle. This unwieldy approach greatly complicates filing copies for use by government, citizens, and emergency-response personnel. It also makes computerization of the information difficult.

In fact, DEP believes development of a centralized, computerized database is es-

Citizens point to horror stories about the tragedies toxics might cause, while industry warns of economic disasters.

sential to monitor compliance and easily summarize information. Edward Stevenson, manager of DEP's right-to-know program, says, "The computerized database is the heart of the program. Without it we'd have files of information and no way to analyze what they really mean."

The New Jersey statute also explicitly mandates a system for disseminating surveys to make information easily accessible. Employers must send copies of completed surveys to state agencies and county health departments, which are required to fulfill citizen requests for information. Businesses also send completed surveys directly to their local fire and police departments.

New Jersey's right-to-know law puts the burden of proof for trade-secret claims on businesses. Specifically, employers must substantiate explicit criteria for withholding information from the public. But companies can contest agency rulings through a multi-stage appeal process. Perhaps most significantly, agencies receive complete survey information so that development of a comprehensive database is possible. Trade-secret protection extends only to restricting public access to information.

The New Jersey statute also includes provisions particularly vital to workers. (Owing to court rulings, regulations specific to workplace concerns apply only to those employers who are not covered by similar federal requirements.) For many in both industry and the labor movement, requirements to train employees regarding workplace hazards are the most significant element of such laws. Labels on containers are also crucial to protecting workers, but how extensive labels need to be for emergency response and community protection is currently being disputed in the courts.

Turning a legislative mandate into reality depends on funding and enforcement powers. The New Jersey statute gives state agencies explicit authority to make employers comply with the law. The agencies can levy penalties for thousands of dollars. Unlike many other right-to-know laws, the New Jersey legislation included sufficient funds for start-up costs, which enabled government agencies to hire personnel to plan programs and develop regulations. But day-to-day operations, subsidized by employer fees of two dollars per employee, are under-funded, so government agencies are looking to the legislature for additional appropriations.

The Evolution of Right-to-Know Laws

Although the power of early right-to-know campaigns might have caught the business community off guard, the desire for some way to exert individual control over toxic hazards had been building for years. A right-to-know campaign was often a convenient and practical peg for the anger, fear, and helplessness that many felt in response to what they saw as a chemical plague not of their making and not under their control.

The optimism of Earth Day in 1970 and the passage of ambitious environmental-protection and occupational-health laws led many people to assume that a clean environment was attainable. They also assumed that government was able to do the job. The debate often centered on land-use planning and development issues, sometimes simplistically reduced to "green space versus greenbacks." That dichotomy caused tension, if not outright hostility, between environmentalists and workers.

But headlines about Love Canal in 1978, followed by other frightening news stories, led to a growing realization that more was at risk than birds and trees. The crusading spirit of the early environmental movement gradually changed focus to environmental health issues. Inspired by Ralph Nader's successes, activist groups such as Massachusetts Fair Share began organizing around abandoned hazardous-waste sites.

During the mid-1970s, union health-and-safety activists coined the term "right to know" to describe their demands that OSHA issue a standard requiring companies to give employees access to information about workplace chemicals. After meeting resistance from OSHA and overwhelming industry opposition, unions modified their strategy and fought for state laws in addition to advocating the comprehensive protection of a federal rule.

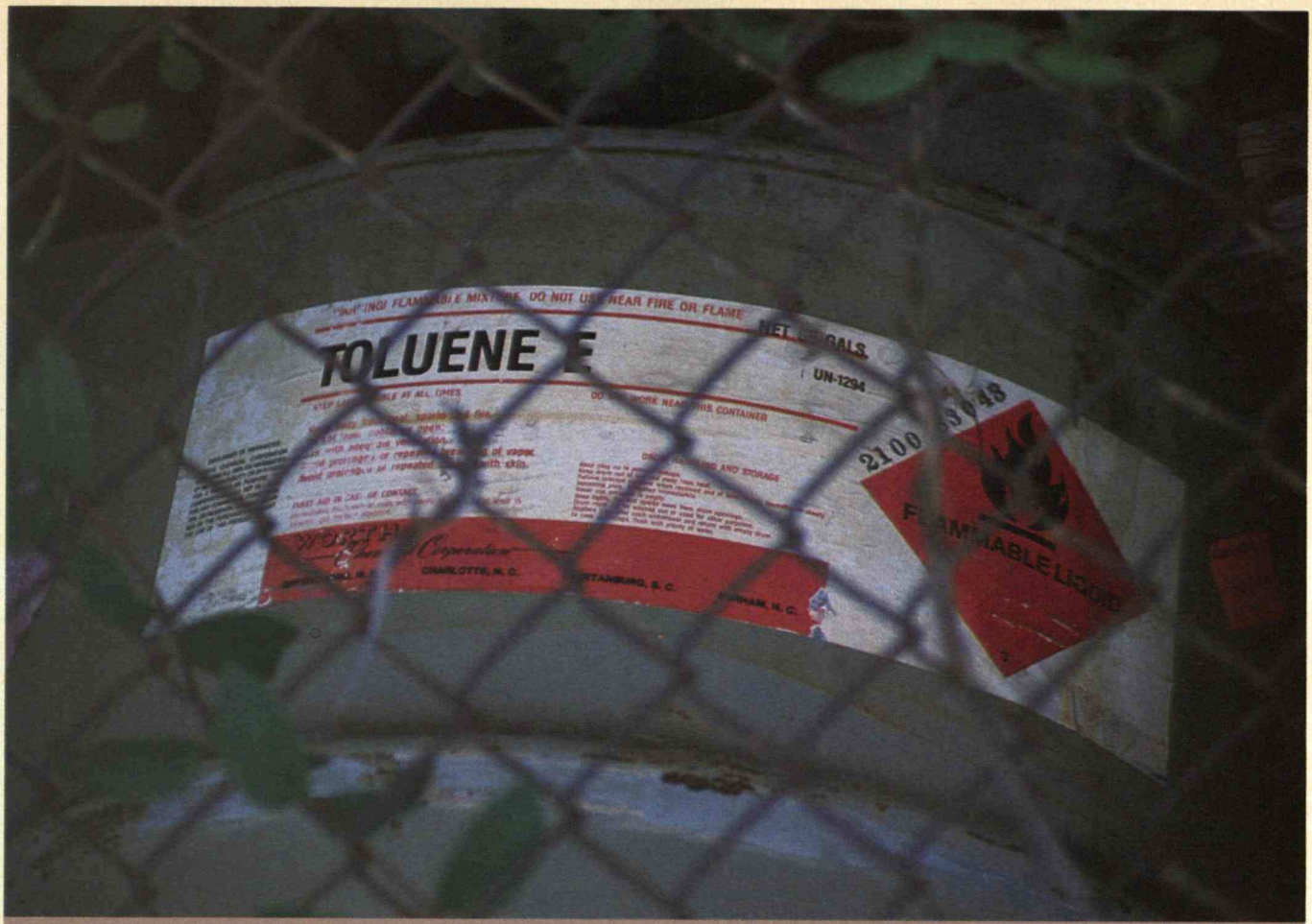
In Philadelphia, union, environmental, and community groups joined together to overcome business opposition that none could have successfully faced alone. The Philadelphia victory was a concrete indication that labor unions and environmental organizations had realized they might have a lot in common: the chemicals workers were exposed to on the shop floor had the potential to affect those who lived beyond the plant gate. The right-to-know issue linked union health-and-safety concerns and community fears to a seemingly basic American right—access to information. The right to know became a golden issue for rallying people and moving legislators.

The Business Response

Rarely will anyone overtly oppose the concept of a right-to-know law, which seems a mom-and-apple-pie issue. Nevertheless, the battles for the legislation, as exemplified by the Philadelphia campaign, have been explosive. Citizens point to horror stories allegedly caused by toxics, while industry warns of economic disasters allegedly caused by passage of such laws.

The specific legislative provisions, which determine the potential of a law to provide meaningful information, often provoke fierce debate. For example, the business community usually agrees that labeling containers holding toxics might improve worker health and safety. But industry often strongly resists labeling with specific chemical identities, preferring instead generic labels or hazard warnings. Unions counter that in the past industry has withheld vital information about hazards and therefore shouldn't be trusted to determine the contents of a warning label. Industry raises objections to the costs of providing detailed labels.

Similar arguments erupt over other specifics. The business community has always been leery of divulging trade secrets. All right-to-know laws afford some protection for trade secrets, but the extent to which business can withhold information is usually a major source of contention. Too much latitude and unions and community groups claim business gets a carte blanche to withhold information. Too little flexibility and businesses claim they lose all competitive edge. For example, a perfume manufacturer has an interest in preventing competitors from knowing the ingredient that gives its leading brand a particular charm. But without clear criteria for what constitutes a trade secret, the manufacturer could withhold information about many ingredients unlikely to be trade secrets. In essence, the debate hinges on how to balance two needs: the need for workers and the public to know about potential exposure to toxic chemicals, and businesses' need to maintain a competitive advantage.



Workers and managers agree that labeling toxics might be important for health and safety. But they often argue fiercely about what information the labels should include.

Some executives are also wary of the costs of implementing right-to-know laws due to the expense of disclosing information about the health effects of toxics, labeling containers, and training workers to safely handle materials. Small businesses find these costs particularly burdensome. OSHA estimated the costs of initiating compliance with a federal standard that includes all these components to be $42 per employee. Some companies cite substantially higher costs, but OSHA says it would be difficult to conduct studies to verify the agency's original estimates. Despite short-term costs, activists claim failure to implement right-to-know programs can result in untold human suffering and potentially greater long-term costs to both industry and society. They give as examples the cost of cleaning up abandoned hazardous-waste sites and the difficulties of asbestos manufacturers now potentially liable for hundreds of millions of dollars in damages from workers dying of cancer.

Paradoxically, some companies express concern about increased liability resulting from disclosure of information. It's easier to bring a case linking toxic exposure to adverse health effects when information is available. But Larry Gallo, manager of state issues for the Chemical Manufacturers Association (CMA), comments, "Any potential liability connected to full disclosure is a better situation than potential liability connected to lack of disclosure."

Although there has been a shift in attitude by the more enlightened members of the industrial community, executives are often reluctant to divulge information since they fear public reaction. In the face of the hysteria with which citizens have been known to react to siting of hazardous-waste facilities, as well as general "chemophobia," some industries are understandably reluctant to let citizens know that the business down the block uses anything more ominous than table salt. In response to presentations of employer responsibilities under New Jersey law, plant managers have also expressed concern about whether employees will continue to work when told of health hazards.

However, studies by Paul Slovic and Baruch Fischhoff, leading researchers in the growing field of risk perception, indicate that people tend to be less fearful when they feel they have some control over a situation. Access to information, such as that provided under many right-to-know laws, can be a prerequisite for exerting such control.

In January 1986, the National Science Foundation issued a draft report concerning communication of chemical risk. This report noted that trust is another factor determining citizen reaction to situations involving toxic chemicals. In fact, there is an evolving consensus on the part of industry and government that developing credibility and winning public trust are essential to making progress on vital toxics issues, such as siting hazardous-waste facilities. Divulging information may be a significant variable in winning such trust, and right-to-know laws may be a step in that direction. "We will never return to the days when we were content to let people in white coats make soothing noises," Lee M. Thomas, administrator of the federal Environmental Protection Agency

Continued on page 50

PHOTO: LAURA DREY

Armageddon in North Carolina

BY DEE REID

When residents of a low-income neighborhood in Durham, N.C., saw a white cloud hovering over their heads one evening in March 1983, they knew immediately it was Armageddon—that is, Armageddon Recycling Co. For months, the company had been treating and storing hundreds of barrels of toxic chemicals, including many carcinogenic and flammable substances.

A drum of recently distilled industrial solvent had erupted inside the plant. The resulting fumes forced east Durham residents out of their homes for five and a half hours. Two public-safety officers—who weren't equipped with face masks—were overcome by toxic fumes while lugging the leaking drum from the building.

State officials later concluded that the barrel of solvent had been tainted with another chemical, apparently before it had arrived at the recycling plant for treatment. The workers at Armageddon had had no way of knowing that an unidentified ingredient would cause the container to explode.

It was the type of accident that local residents had feared for some time. Chemicals were regularly trucked through the neighborhood to Armageddon from manufacturing companies in Durham and the rest of the growing Research Triangle area. The company routinely stored steel drums outside on an unpaved lot. Some of the 55-gallon containers were rusty and leaked chemicals onto the ground. Some of the barrels were labeled only with question marks.

Not long before the Armageddon explosion, the Durham-based North Carolina Occupational Safety and Health Project (NCOSH) had begun organizing a coalition of public-interest, labor, and health groups to work toward enacting "right-to-know" ordinances at the local and state levels.

NCOSH had documented many incidents in which workers who had become sick on the job had lacked vital information about the chemicals they had been exposed to. The plant called Armageddon and barrels labeled only with question marks provided a graphic example of the need for more information about chemicals in the workplace and community.

In the wake of the Armageddon incident, NCOSH and a new grass-roots organization called Citizens for a Safer East Durham (CSED) told the city council about the advantages of a local right-to-know ordinance. "If a right-to-know ordinance had existed at the time of the explosion at Armageddon, we would have known how to deal with that situation," says Gloria McRae, president of CSED. "Durham's question marks were stored there for a long time. The community had a right to know what we were exposed to."

McRae and the coalition found an ally in city councillor Tom Campbell. "This all took place before there was a federal 'right-to-know' ordinance or even talk of a state ordinance," recalls Campbell. "I took the opportunity to say that the City of Durham needed some protection."

The city council appointed Campbell to head a subcommittee to look for solutions to the problem of insufficient information about toxic substances being used, treated, and stored in Durham. In August 1983 the council approved the subcommittee's resolution calling for the city to draft an ordinance that would require more complete labeling of all hazardous materials. The council appointed a citizen advisory committee to help draft this ordinance. The committee was composed mostly of scientists who worked for local employers and representatives from the chemical industry.

Meanwhile, toxic substances became an issue in the city-council elections. The right-to-know coalition—now known as the Durham Toxics Coalition—endorsed a slate of liberal candidates that won the majority of seats in the new council. After the election, the council enlarged the advisory committee to include broader interests. The new citizen advisory committee included representatives from labor unions, the east Durham community, consumer and public-health organizations, NCOSH, and local industries.

The committee had its work cut out. "It was difficult because only a few places had local right-to-know ordinances," says Campbell. "We were definitely plowing new ground."

By the summer of 1984 the committee had drafted a right-to-know ordinance and was ready to solicit public comment on it. At a series of public hearings, health experts, labor-union officials, and other citizens spoke overwhelmingly in favor of the ordinance. Almost no one at the hearings opposed the ordinance. Shirley Osterhout, director of Duke University

These barrels labeled "blue goo" were stored at the Armageddon Recycling Co. in Durham, North Carolina. After

PHOTO: LAURA DREY

an explosion at the plant, citizens pushed for a law that would require more useful labeling.

Medical Center's Poison Control Center, called it "one of the most important acts of government that has been presented in Durham."

A month after the final public hearing, the city council received written statements from the Greater Durham Chamber of Commerce and Liggett and Myers (L&M), the city's largest manufacturing employer. A 30-page L&M memo addressed several concerns, the most prominent being the company's fear that extensive labeling of chemicals used in the manufacturing process would reveal trade secrets.

The chamber's letter reiterated the trade-secrets issue, and added another worry. What if the industries flocking to the Triangle decided it would be easier to locate in neighboring areas that had no local right-to-know regulations? The ordinance would be "a liability if it results in Durham being perceived as a community which gives little credence to the legitimate concerns of responsible industry," wrote chamber representative Jeffrey P. Downin.

Eventually, the citizen advisory committee produced a revised ordinance that seemed to satisfy all sides. "We compromised some," recalls Dave Austin, a member of the committee and the director of NCOSH. "But most of the compromises seemed to make sense."

The ordinance required each local industry to report the identity and health hazards of all toxic chemicals used, handled, or emitted. That information would be available to workers, community residents, health-care providers, and emergency-response personnel. The ordinance allowed companies to protect their trade secrets while providing enough information on the label to protect workers and the public.

On May 6, 1985—a little more than two years after Armageddon—the 13-member city council unanimously approved the ordinance, making Durham the first municipality in the Southeast to adopt a right-to-know law.

Durham's law was probably also the most short-lived right-to-know law in the country. About a month after it was enacted, the North Carolina General Assembly passed a similar, somewhat weaker law. The state law effectively preempted everything Durham had done: North Carolina municipalities may not enforce local ordinances that are stricter than whatever state law corresponds to those ordinances. Durham's stricter ordinance made it more difficult to get an exemption for a trade secret, called for more frequent inspections, and included a more comprehensive list of substances that would have to be labeled.

Some local political activists believe Durham industries worked quietly for the state law because it would be less stringent than the city ordinance. And Republican Governor Jim Martin, a former chemistry professor, opposed the right-to-know concept, arguing that it would give citizens more information than they need and also would lead to "chemophobia."

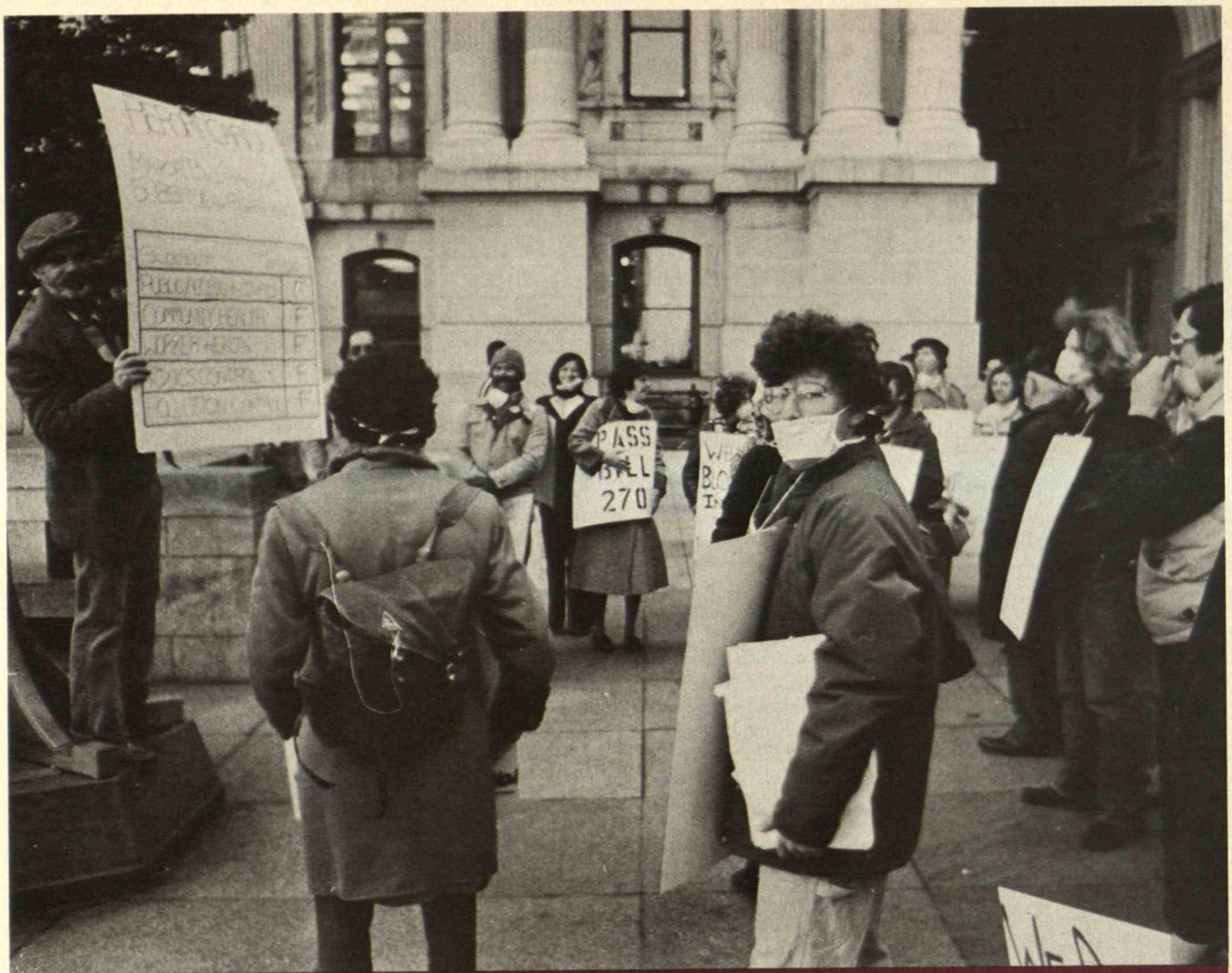
Nevertheless, both Campbell and NCOSH feel their work on the local ordinance had a lasting effect at both the state and local levels. "We feel the passage of a state right-to-know law was a victory," said Austin. "It was the pressure from our local ordinance that gave the state law a chance."

Campbell agrees. "The state law didn't compromise on the principle of making information available to the public and ensuring them that hazardous materials would be handled more safely." Environmental lobbyist Bill Holman called it "a program to work on and improve in future sessions." And indeed, in the 1986 legislative session NCOSH is asking the General Assembly to appropriate funds for stricter enforcement of the new law.

What's more, Campbell said that because of the council's work on the right-to-know ordinance, "we have a much better awareness of the dangers of toxic substances." Since acting on the ordinance, the council has made changes in the local zoning code to restrict the areas in which hazardous-waste facilities can be located. And, for the first time, a team has been set up in the local fire department to respond to situations involving hazardous materials. The creation of the team led to a need for specialized equipment and training to enable fire fighters to deal effectively with chemical accidents.

Perhaps even more important to the residents of east Durham, Armageddon was sold to an out-of-state company. The new owners eventually concluded that cleaning up the plant was not worth the trouble. Armageddon has been shut down. □

DEE REID is a free-lance writer living in Pittsboro, N.C. She has six North Carolina Press Association Awards.



During the Philadelphia campaign for a right-to-know law, citizens gave Mayor William Green flunking grades in a number of subjects affecting public health.

(EPA), told a conference recently. He added, "The public must share directly in decisions that affect it, and we must ensure that it does so with a fuller understanding of the inevitable trade-offs involved in the social management of risk."

The Legal Arena

However, even the most enlightened companies have been alarmed at the growing proliferation of right-to-know laws. The most forward thinking would opt to disclose information voluntarily or submit to legislation that grants a great deal of flexibility, rather than comply with stringent regulation that determines the data to be divulged. Corporate executives also point to compliance nightmares caused by satisfying the requirements of right-to-know laws that vary from state to state, and in some cases from city to city.

To correct the situation, industry pushed for what unions considered a relatively weak federal standard soon after Ronald Reagan became president. They wanted a standard that would preempt state and local laws. In 1983 industry was granted its wishes when OSHA finalized its Hazard Communication Standard, a federal regulation giving manufacturing workers access to information.

Immediately right-to-know supporters—including the AFL-CIO, the United Steelworkers of America, a number of states with right-to-know laws, and Ralph Nader's Public Citizen—challenged the OSHA standard in court. The unions charged that because the federal standard covers only manufacturers, it doesn't address serious chemical hazards in other workplaces. Furthermore, they contended that the trade-secret provisions are too broad. According to an AFL-CIO analysis, the provisions create "a loophole that threatens the rest of the standard." The states vigorously disputed the standard's stated attempt to preempt their laws.

This lawsuit marked a turning point in the right-to-know movement. Unions had previously championed a national standard, but now they were in court over a federal regulation. After vigorously opposing efforts during the Carter administration to impose federal requirements, industry backed the new standard. An administration that had come to office espousing states' rights had promulgated a regulation with the goal of preempting state authority.

PHOTO: BILL BARRY

Though the Reagan administration has espoused states' rights, it promulgated a regulation preempting state authority.

The Third Circuit Court of Appeals ruled in 1985 that OSHA must strengthen its regulation by covering more types of businesses and revising trade-secret procedures. But in a blow to proponents of state right-to-know laws, the court also ruled that provisions of state laws relating to *workers* were superseded by the federal Hazard Communication Standard. The ruling left open a central question: Did the states have the authority to legislate disclosure of information to the *public*?

Anticipating that question, industry had earlier initiated another court battle. In 1984, as state agencies were gearing up to implement New Jersey's right-to-know law, a number of business trade associations (including the New Jersey Chamber of Commerce and the state's Chemical Industry Council) and major manufacturing firms (such as Exxon and Merck) took the state to court to block implementation of the law. They said the OSHA standard preempted all portions of New Jersey's right-to-know laws.

The lawsuit has been a benchmark for the right-to-know movement. A New Jersey deputy attorney general and a team of lawyers for more than 20 labor and public-interest groups presented complex legal arguments. The Third Circuit Court of Appeals decided to allow New Jersey to implement provisions of the law that do not concern workers and therefore are not covered by OSHA—those related to community and environmental hazards.

This latest appeals-court ruling did not completely usurp state authority to implement right-to-know laws. On the other hand, industries were relieved that they were no longer required to comply with a multiplicity of state provisions regarding disclosure of information to workers and labeling of containers.

The Results

More than a decade of debate over industry disclosure of information has not resulted in an obvious exodus of businesses from those locales with right-to-know laws. Nor has there been a dramatic reduction in toxics problems. But no one has conducted a comprehensive survey of how government agencies, let alone citizens, use right-to-know laws.

New Jersey has pioneered some applications of a toxics database. As part of a project that preceded passage of the state's right-to-know law, DEP surveyed manufacturing facilities for detailed information about the use and release of 155 chemicals that have the potential to cause chronic health effects or environmental problems. Despite far fewer powers than are provided under the right-to-know law, DEP collected data vital to discovering a number of sites that were contaminated with dioxin, a highly toxic substance.

In addition, as described in the Industrial Survey Project Report issued by DEP's Office of Science and Research, the survey data help the agency enforce existing environmental laws by providing reliable estimates of chemicals companies handle. For example, one New Jersey law says that before certain types of companies can sell their facilities, they must demonstrate that those facilities are free of chemical contamination. Checking industrial survey information assists in a more thorough investigation of a company.

Finally, the survey data has been used in a number of research efforts. For example, INFORM, a non-profit research organization, has used the data as part of a national in-depth study of production and reduction of hazardous wastes in the chemical industry. INFORM's report noted that because DEP's data were so comprehensive, the profiles of 11 New Jersey plants were far more complete than those of facilities in other states.

According to Henry Garie, assistant director of DEP's Office of Science and Research, "We've always hoped that the right-to-know database, which is much more comprehensive and sophisticated than the industrial survey's, will increase our understanding of the fate of toxins in the state."

DEP plans to use the right-to-know database to help implement a legislatively mandated program aimed at averting disasters such as Bhopal. Any business that reports substances specified by DEP as unusually hazardous will be targeted for follow-up activities. These could include requiring the company to revise or establish emergency-response procedures. DEP also plans to make the right-to-know data available to the agency's emergency-response staff and state police for contingency planning and emergency-response purposes.

Despite the fact that legislative amendments and court orders have delayed implementation of New Jersey's right-to-know program several times, a public hearing on its implementation in March 1986 pointed out immediate benefits—and problems—derived from the law.

According to R.K. Associates, a consulting firm hired by schools to assist with compliance, initial inspections indicated that chemicals were being stored unsafely and in unnecessarily large quantities. The consultant said that schools, alerted to these hazards, had made significant efforts to correct the conditions, although the right-to-know law does not require such efforts. The Garden State Water Co. submitted testimony stating that it "has had an increased awareness of all safety issues as a result of our right-to-know training." The company's letter noted that many of its employees commented during training "about safe chemical handling at home as well, so the effect of the law has reached outside the workplace."

Progress has not occurred without a price. Many employers complain about difficulty complying with the law, particularly the more costly provisions requiring training of employees and labeling of containers. While praising the objectives of the act, the water company expresses widely felt concerns: "The law would have us label every single container, and in our case that is burdensome and unrealistic. . . ." Employers are also frustrated by multiple survey forms from different state agencies. The agencies are now attempting to merge their forms.

Massachusetts, which also has a fairly comprehensive right-to-know law, reports some significant progress in the midst of the usual implementation problems. The unique Massachusetts system requires state and municipal governments to validate citizen requests for information before making the data available. This approach, proposed by industry, is seen by citizen groups as a stumbling block. Ironically, it may help improve public health by speeding action on the complaints citizens make.

Alecia Agan, director of the community aspects of the Massachusetts right-to-know program, cites an example in which citizens asked for information about a facility storing toxins. The citizens alleged that storage was improper and that barrels leaked. The local fire chief responded by conducting a routine inspection and checking with municipal agencies for any records of violations. He concluded that the facility was so mismanaged that it was an imminent danger to the community. The Massachusetts Department of Envi-

Last year medical expert Irving Selikoff (far right) joined labor and environmental leaders in supporting a controversial bill. The legislation would allow workers to learn if their jobs put them at a high risk for disease.

ronmental Quality Engineering agreed. As a result, the request for information triggered a coordinated government response to the dangers posed by the business. According to Agan, further investigations by the state revealed other facilities under the same ownership that were also dangerous.

Agan reports other instances in which citizen petitions for information alerted the government both to non-compliance with the right-to-know law and to flagrant violations of other state laws concerning handling and transport of hazardous wastes. In addition, she believes the Massachusetts program, which applies to public-sector and private-sector employees alike, is forcing government to become aware of and correct unsafe conditions in its own facilities. For example, Agan says the growing awareness fostered by the right-to-know law is stimulating the removal of asbestos from public buildings. "You shouldn't measure a program just by its legislative mandate but by its ripple effect," Agan points out.

Although the incidents have not been widely publicized, workers have been able to use information provided under the right to know to dramatically improve their lives. "Right to know is an important first step in the process of finding out what the exposure is and making the connection between exposure and illness," says Nancy Lessin, director of the Massachusetts Coalition on Occupational Safety and Health, a union-based organization.

His ankles twisted and legs atrophied, a Philadelphia chemical worker was convinced that he had multiple sclerosis. With the assistance of the union-based Philadelphia Project on Occupational Safety and Health, the worker used the city law to obtain a partial list of the substances to which he had been exposed. Based on this information, his doctor could attribute his condition to chemicals rather than multiple sclerosis. When the doctor treated the worker accordingly, his condition improved dramatically.

But unions admit that the laws are underused. Lack of education is part of the problem. "The law is not worth the paper it's written on unless workers are trained in how to use it," says Lessin.

Many citizen groups see right-to-know legislation as an essential first step to deal with larger environmental issues. Two incidents in San Diego highlighted the message of the Environmental Health Coalition, a citizen group, that the city needs more rational land-use planning. In one case, an airplane made an emergency landing next to a plant doing research connected with biological warfare; the plant is located in the same complex as facilities that handle hazardous materials. The entire industrial park is located under a U.S. Navy flight path. In the second case, an explosion in an industrial park forced evacuation of a nearby school. The Environmental Health Coalition has started to develop chemical profiles of several areas using data collected under the city's right-to-know law. Based on results of their study, the coalition plans to recommend improvements in the zoning process. In essence, the coalition is undertaking a study that might be considered government's responsibility in order to push local government to take action.

Fire fighters might benefit more than any other group from right-to-know laws, particularly given the greater attention paid to preventing and responding to chemical emergencies since the Bhopal tragedy. Richard Duffy, director of health and safety for the International Association of Firefighters, says that access to information is partially responsible for the additional attention fire fighters give to hazardous materials. Because of this, Duffy has made it a point to testify about and support right-to-know efforts around the country. While admitting that information available under right-to-know laws isn't yet used extensively, Kim Mueller, Duffy's California counterpart, points to several cities where that information is computerized for fire fighter use.

Others see the right to know as overrated. George Kramer, hazardous-materials specialist of Tennessee's Emergency Management Agency, says information won't help fire fighters much unless they have computer printouts under their noses. And that is unlikely to happen without a lot more resources allocated to fire departments. On the other hand, Kramer thinks state agencies can use right-to-know information to plan their response should an emergency occur.

The CMA's Larry Gallo sees little relationship between right-to-know laws and public health. He stresses that the industry has always made safety a priority and that the increasing emphasis on dis-

PHOTO: RAY CROWELL, PAGE ONE PHOTOGRAPHY

One activist declares, "Essentially the right-to-know battle has been won."

closure has not changed that.

Many question the validity of right-to-know laws because of the limited number of citizen requests for information available under the legislation. But Alecia Agan again warns against judging a law by that criterion. Agan, along with officials in other states, union leaders, and citizen activists, notes that little is done to make those who might use right-to-know laws—from doctors to fire fighters—aware of the legislation's potential. For the most part government has failed to develop educational programs, so the responsibility usually falls upon under-funded and overburdened nonprofit organizations. As Susan Sherry, environmental health director of Golden Empire Health Planning Center, explains, "Whether the public should have access to information is [a] different [question] than who uses it the most."

Government bodies might not take action on hazardous chemicals unless citizens push for it. By giving officials additional powers to deal with the problems their constituents bring up, the Massachusetts right-to-know law could help improve public health.

The Future of Right to Know

The concept of information disclosure has gone from being a relatively obscure union issue to one debated in state legislatures and all three branches of the federal government. Currently, several major federal environmental bills contain right-to-know provisions. Passage of federal legislation that would give the public and fire fighters some form of access to information may be inevitable.

However, some long-term right-to-know activists, who watched the evolution of the OSHA Hazard Communication Standard, have mixed feelings about the federal bills. Proposed federal legislation may have significant flaws and impede further legislative action on the state level. On the other hand, federal legislation will reach states unlikely to take their own initiatives and might expand the authority of states with limited right-to-know laws. The OSHA standard, which the agency is under court mandate to explore expanding to more workplaces, has also reduced the pressure for state legislatures to take action. As Janis Adkins, editor of the *Right-to-Know News*, explains, "The nebulous federal activity is like a cloud hanging over the states."

The Bhopal disaster has acted as a catalyst. Ken Silver, research director for the citizen-based National Campaign Against Toxic Hazards, believes that "Bhopal changed the nature of the debate from whether there should be a right to know to what kind of right to know." Susan Sherry credits the influence of Bhopal for the relatively easy passage of California's law. And the CMA is urging its members to join its Chemical Awareness and Emergency Response Program (CAER). This approach encourages plant managers to voluntarily discuss emergency-response plans with community representatives. EPA, which for the most part had stayed out of the right-to-know debate, recently developed a Chemical Emergency Preparedness Program in response to Bhopal. The program, which is based on an EPA-identified list of some 400 extremely hazardous substances, is a voluntary one similar in many respects to CAER.

Activists scoff at the notion of businesses voluntarily surrendering complete information on the identities and amounts of toxics. They see such programs as a ploy to avoid stringent, compulsory legislation. But the energy invested in such high-profile programs indicates how far the debate has progressed. Gallo states, in response to questions about the association's evolving position on disclosure of information, "If the collective policies of CMA bring the rest of the industry to sharing chemical information, then we have achieved a great goal." Such a statement would have been unlikely 10 years ago.

Rick Engler, who was associate director of the Philadelphia Area Project on Occupational Safety and Health, an organization with a key role in four major right-to-know campaigns, declares, "Essentially the right-to-know battle has been won." He advocates a next step, termed right to act, which would involve workers in enforcing occupational health regulations at local levels. The right to act would include, for example, the right to refuse unsafe work without first resorting to courts or other government agencies.

Right-to-know initiatives were brought about by citizens who felt they had to know what was behind the factory gates because government wasn't looking hard enough. These citizens concluded that they needed the right to look themselves. But having won the battle, people may not feel the same sense of urgency to demand information as they had felt when they believed data were hidden. Unless concepts like the right to act catch on, significantly protecting public health may depend on how extensively government uses the information for which activists have fought. And in some cases, that government action may depend on citizens taking the lead. □

PHOTO: RICK GOODWIN, NORTH SHORE SUNDAY

CONTINUED FROM PAGE 4

out a tax increase. What nonsense!

Of course, taxes give people privileges, and it is difficult to take those privileges away. But it is not impossible. For example, there is plenty of room for cuts in the military retirement system. Many officers retire at age 45 or earlier at a rate of pay that gives them a higher standard of living than they ever achieved while on active duty. They also receive continued free medical care, access to tax-subsidized stores, and free flights on government airplanes for overseas vacations.

Gramm-Rudman *is* flawed. But the real problem is that congressional districts have been gerrymandered in favor of liberals. As a result, the last elections produced a House of Representatives that is not amenable to the popular conservative trend, and the Senate and President Reagan have not been able to act effectively. If they had been able to act effectively, Gramm-Rudman would not exist.

GEORGE E. WILLIAMS
Naples, Fla.

WEIGHING HEALTH RISKS

Dale Hattis and David Kennedy have presented a clear and precise discussion of a subject that is all too often misunderstood (*"Assessing Risks from Health Hazards: An Imperfect Science," May/June, page 60*). Risk assessment cannot conclusively solve important policy problems. It is valuable principally because it gives decision makers a number of realistic approaches to choose from. Ironically, the technique is misused and misrepresented with equal ardor by proponents and opponents. Thus, the public has become more and more befuddled.

I especially appreciate the clear message that because risk assessment is often imprecise, it will not obviate the need for value judgments. The public and policymakers have to understand that such judgments lie at the heart of any decision about health hazards.

NORMAN STEISEL
New York, N.Y.

ANIMAL RESEARCH

It was gratifying to read Andrew Rowan's article advocating that scientists find alternatives to animal use (*May/June, page 22*). When professionals work within the framework of nature and morality, they will make real progress.

CHARLES G. SANTORA
St. Petersburg, Fla.

SOMEDAY, POOR VISIBILITY WILL BE SOMETHING YOU JUST DON'T SEE ANYMORE.

At GM, our concern for safety goes beyond safety belts and disc brakes. We're working on advancements in electronics to help you actually avoid accidents.

Night vision is an infrared imaging system. It senses the difference in temperature between an object and its background, then displays an enhanced image of what's out there on a screen. GM is working on the technology now, and somewhere down the road, it could be in your car.

So in fog, rain, snow or darkness, you'll be better able to see what's on the road when you can hardly see the road.

THE GM ODYSSEY: SCIENCE NOT FICTION

GM

Controversy is mounting over opposing technologies to keep electronic communications confidential. One would protect only the interests of large organizations; the other would protect individuals' privacy as well.

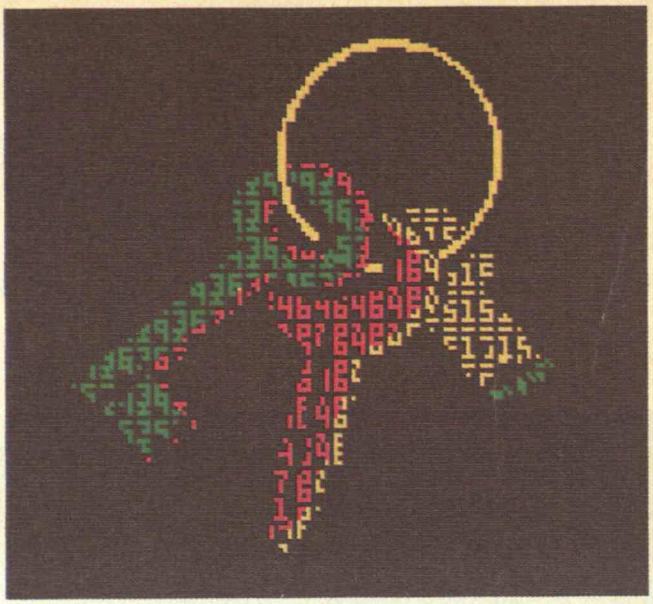
ILLUSTRATIONS: OLGA ANTONOVA

EN-CRYP-TION

TECHNOLOGY, PRIVACY, AND NATIONAL SECURITY

BY TOM ATHANASIOU

COMPUTER encryption systems are the wax seals and envelopes—or better, the locks and keys—of the electronic age. Encryption is widely used to scramble electronic communications and thus keep them confidential. The signals that travel between the teller machine and its mainframe host computer are encrypted, as are the signals beamed down from spy satellites. High-level diplomatic communications are almost always encrypted, and increasingly, high-level corporate communications are as well.



Electronic cryptography can protect any digital message—any message communicated in a stream of binary digits, or "bits." A "key"—a series of bits—is fed to the encryption device to scramble the message. Only the holder of the right digital key can translate the message back into unencrypted "cleartext."

Destined to help shape our future, encryption technology has not itself been finally shaped. Competing lines of development exist, and they have very different social implications. Conventional encryption—the kind championed by the National Security Agency (NSA)—works much like a combination mailbox. Anyone who has the combination (the digital key) can lock and unlock the box (send messages and decode other messages sent with the same key). Since senders and receivers must exchange secret keys, conventional "ciphers," or cryptosystems, are best suited to a limited set of users. Systems of this type are common in military, diplomatic, and financial communications; they are widely known and in many ways define the public perception of encryption. Unfortunately, they couldn't serve as the basis for security in an extensive electronic communications system open to use by many individuals.

"Public-key" encryption systems, though less commonly understood, could serve in this way. According to former NSA director Bobby Inman, the agency discovered and classified public-key encryption in the early 1970s. In 1976 cryptologist Whitfield Diffie and Stanford professor Martin Hellman rediscovered public key and published a paper describing the idea. Today, public key remains an idea in development, though RSA Data Security in Redwood City, Calif., is already marketing one system.

Public-key systems work like mailboxes with two different combinations, one for locking and one for unlocking. The locking combination (the "public" key used to encrypt messages) can be given out freely, so that anyone can, in effect, put a letter into your mailbox. But you keep the unlocking combination (the decryption key) secret, so only you can remove letters. Since senders and receivers never need to exchange secret keys, individuals could ask friends, businesses, or even strangers to encrypt messages to them.

The implications of the concept become clear only when we think of a system in widespread and routine use, with public keys in directories like phone books. Both individuals and institutions could use the keys to secure phone calls, electronic mail, and other telecommunications. The possibilities are enormous, and the main point is clear: this approach doesn't require citizens to trust institutions any more than institutions are required to trust citizens.

One recently proposed adaptation of public-key cryptography offers even more benefits. Civil libertarians are concerned about the increasing ease with which large organizations, whether governmental or private, can amass extensive electronic dossiers on individuals—records of who they telephone, where they've worked, how much money they spend, whether they've been arrested (even if later acquitted). In this adaptation, public-key systems would employ "digital pseudonyms" to short-circuit the collection of dossiers while still making it possible to conduct the bread-and-butter transactions of an information economy—electronic purchases, credit verification, and so on.

Secret Cryptography

In conventional ciphers, the "algorithm," or mathematical method by which signals are scrambled, is itself often classified. Proponents say this helps strengthen the cipher, but the matter is unclear. In any case, public-key systems can be designed so that disclosure of their algorithms poses no security threat. Knowing the internal workings of the cipher doesn't help to break it; individual messages still can't be deciphered without the secret decryption

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Computer encryption systems are the locks and keys to protect electronic communications.

key. Those who favor public key often assert that this kind of open approach is characteristic of modern cryptography.

How is such elegance achieved? By basing ciphers on mathematical problems that are, in the understated lexicon of theoretical mathematics, "hard." Deciphering a message without the key would require solving one of these problems. There are many, and some have resisted solution for thousands of years. If mathematicians make sudden progress on one of them tomorrow, it will be news. Anyone using a cipher based on the problem would immediately know.

Advocates of public-key cryptography fear that it is being squelched by NSA, the most powerful exponent of conventional ciphers. Though its budget is estimated to be five times greater than the CIA's, NSA is so secret that for many years the government denied that it even existed. Today, it's known that NSA has two primary functions. The first one—"signals intelligence"—consists primarily of intercepting messages deemed critical to national security. The agency routinely monitors phone calls to and from the United States, and a Senate intelligence committee report stated that between 1967 and 1973, NSA illegally spied on 1,200 Americans chosen for their political activities. NSA's second role is "communications security"—protecting the United States from foreign spying. In this capacity the agency has set out to market a new family of encryption systems.

These ciphers are to be sold as pre-sealed and tamper-resistant integrated circuits: the encryption algorithm hidden within the chips will be classified. It will remain unknown even to the engineers who will incorporate the chips into security devices for computers or telephones. Critics fear that such secrecy offers NSA the chance to build a "trap door" through which it could decipher messages the senders think are secure. "With a hardware black box you can describe several schemes that would be almost impossible to test for from the outside and could, in effect, constitute a hardware Trojan Horse [i.e., trap door]," says Herb Bright, an officer of the private data-security firm Computation Planning Associates. Bright is a member of the American National Standards Association/American Bankers Association committee that is evaluating NSA's new ciphers.

NSA proposes a strange way for users of new ciphers to obtain keys for encoding and decoding. The agency hopes to provide these keys itself. It will assign keys to all government agencies using the systems, while civilian users will have the choice of obtaining keys from NSA or generating their own. However, the second course will be discouraged. Last year Walter Deeley, then NSA deputy director for communications security, told *Science* magazine, "It's not a trivial thing to produce a good key." He went on to insist that NSA wouldn't keep copies of the keys it assigned.

Several factors will help NSA promote the ciphers. Starting in 1988, they will be mandated as the official U.S. civilian encryption standard. The current civilian standard, authorized by the National Bureau of Standards (NBS), and known as DES (for Data Encryption Standard), has come into widespread use among banks, financial services, and government agencies. Although such an encryption standard is officially only advisory, practical considerations dictate its use. For example, if the Federal Reserve switches to a certain system, banks that deal with the Fed will have severe logistical problems if they don't follow suit. And the use of a standard is becoming a recognized measure of legal due care. Suppose a bank uses a non-standard system—one sold commercially but not certified by the government—and a thief alters electronic funds transfers. The bank is far more legally vulnerable than if it had stuck to the standard.

In 1984 the administration put out National Security Decision Directive 145 (NSDD-145), which will help enforce NSA's standard. NSDD-145 gives a committee controlled by NSA authority to set policies concerning a wide range of communications-security issues. The directive specifically designates this committee to oversee "sensitive, but unclassified, government or government-derived information, the loss of which could adversely affect the national security."

The American Civil Liberties Union (ACLU) considers the very category of "unclassified" national-security information dangerous—"a deliberate, calculated effort to expand the realm of what can be considered to be 'national-security' information."

Jerry Berman, head of the ACLU'S Privacy and Technology Project, fears that no one really knows what's to be included in this vague realm. Large inter-bank funds transfers probably qualify, as do high-level communications of major federal contractors. But where does the government draw the line? Warren Reed, director of information management and technology at the General Accounting Office, observes that rulings like NSDD-145 could bring flight-safety information, financial and industrial forecasts, and even medical records under NSA control.

According to *Electronics* magazine, the NSA director is now, for all practical purposes, "setting standards for the entire U.S. data-processing industry." And the Institute of Electrical and Electronic Engineers has gone on record warning against the "dangers we see in implementing the directive's rules for unclassified, sensitive, non-governmental information and private-sector telecommunications." Whitfield Diffie, now at Bell Northern Research in Mountain View, Calif., has said, "I will not be pleased if NSA succeeds in capturing the market for domestic communications-security equipment." Like many other cryptographers, Diffie sees a "great need" for systems designed to protect individual privacy.

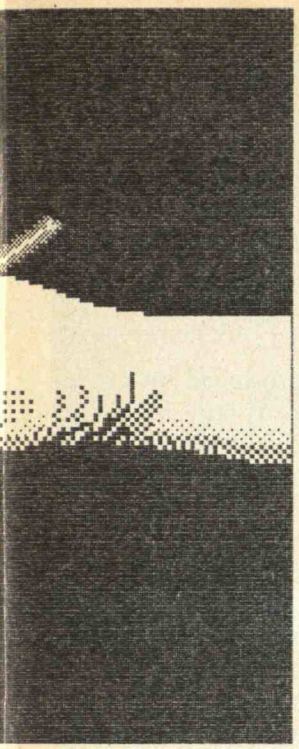
A Peculiar History

NSA's history with civilian encryption technology enforces critics' concerns about the new ciphers. Problems began during the early 1970s, when the agency was involved in codifying DES. In 1973 the NBS called for a national civilian encryption system. IBM was in the final stages of developing its Lucifer system, and Lucifer won hands down. It was by all reports very good—so good that it upset NSA, which had considered itself comfortably ahead of the rest of the world in the still-arcane art of cryptography. Although at the time NSA had no formal role in setting the encryption standard, it was the preeminent government agency concerned with encryption, and NBS felt bound to honor its advice. Rather than approving Lucifer as it was, NSA modified it in several strange ways to create DES.

While Lucifer's key size was 128 bits, DES has a key of only 56 bits, so that it is far more vulnerable to "brute-force" attack. Such an attack is mounted by trying all possible keys—in this case all 56-digit binary numbers—to see which one works. There are 2^{56}—about 7×10^{16} (7 followed by 16 zeros)—possibilities. Large as this number may seem, it is tens of millions of times smaller than the number of possible keys in ciphers approved for military use. The orginal 128-bit key would be much more secure, for it presents 2^{128} possibilities—about 3×10^{38}. Even with today's supercomputers, brute-force attacks would be out of the question.

NSA's weakening of Lucifer appears to have been deliberate. According to David Kahn, the noted cryptography historian who wrote *The Codebreakers*, Lucifer set off a debate within NSA. "The code-breaking side wanted to make sure that the cipher was weak enough for the NSA to solve it when used by foreign nations and companies," he wrote in *Foreign Affairs*. On the other hand, "the code-making side wanted any cipher it was certifying for use by Americans to be truly good." Kahn says the resulting "bureaucratic compromise" made the key shorter. Alan Konheim, former manager of IBM's Lucifer research project, recollects, "If they [NSA] had had their way, they would have had 32 bits. . . . I was told at one time that they wanted 40 bits, and at IBM we agreed that 40 was not enough."

At the same time that NSA shortened Lucifer's key, it used classifed criteria to redesign several numerical tables known as "substitution boxes" or "S-boxes." When a bitstream (a stream of binary digits) comes into DES, it's broken into chunks. The bits in each chunk are repeatedly permuted (that is, rearranged) in a way that depends upon both the key



"Public-key" systems can enable users to sign messages with unforgeable electronic signatures.

and the numbers in the S-boxes. These boxes are thus crucial to the strength of DES, and NSA's critics feel that the changes in them make the system vulnerable to a "cryptoanalytic" attack. In other words, the boxes may now conceal a trap door—a secret numerical regularity that allows NSA to decipher any DES-encrypted text even without the key. NSA's refusal to publish the criteria under which it redesigned the S-boxes has reinforced the critics' fears.

Despite persistent rumors, a trap door has never been found. Years of analysis at institutions including Bell Labs; the Catholic University in Leuven, Belgium; and the Center for Mathematics and Computer Science in Amsterdam have failed to either vindicate or convict NSA. However, mathematicians have unearthed several peculiar properties in the S-boxes—for example, certain numerical regularities that weren't present in IBM's original design. And they've demonstrated the possibility of introducing hidden regularities into the S-boxes that weaken the algorithm. Still, no one has managed to use these findings to mount a successful cryptoanalytic attack on DES. They may mean nothing. But since NSA has never declassified the criteria for redesigning the S-boxes, it's not certain. Because of lingering suspicions, the Swiss and Scandinavians have turned elsewhere for their civilian encryption systems.

The controversy over DES eventually subsided, but in late 1985 NSA suddenly and gracelessly abandoned the system. Directly contradicting years of reassurances, Walter Deeley, NSA's deputy director for communications security, told *Science* that he "wouldn't bet a plugged nickel on the Soviet Union not breaking [DES]." Said Barton O'Brien, sales manager for RSA Data Security, "People in the industry feel betrayed." And according to Herb Bright of Computation Planning Associates, quite an uproar ensued in the normally quiet halls of the American National Standards Institute when NSA announced its new ciphers. Bankers were particularly upset, since they were committed to DES as a means of encrypting electronic funds transfers. NSA was later compelled to announce that DES would remain certified for such transfers.

NSA's new shift raises even more issues. The agency has still declined to declassify evidence that would settle the question of DES's strength. If an avenue of cryptoanalytic attack has been found, then isn't NSA wrong to let banks continue using DES? And if the problem is a brute-force attack, then isn't it a consequence of the reduced key length? Why not just make the key longer?

NSA officials say they don't want to trust the rising volume of sensitive data to DES, because all its major elements except the criteria for S-box design have been widely published. Yet cryptologists are trained to be dubious, and they will never trust a classified cipher. They have more confidence in mathematical intractability. A cipher will be trusted if it is open to independent evaluation and if breaking it is shown to require solving a very difficult numerical problem. Such ciphers do in fact exist and they enjoy a freedom from suspicion that NSA's new ciphers can never hope to share.

Historical evidence suggests that intelligence agencies do promote flawed ciphers under cover. In the most famous case, British Intelligence secretly broke the German ENIGMA machines during World War II. "After WW II, Britain rounded up thousands of ENIGMA machines that Germany had used and sold them to some of the emerging nations," writes David Kahn. This allowed Britain to "keep tabs on what each country was planning." The fact that ENIGMA had been broken in the 1940s remained classified until 1974.

In *The Puzzle Palace*, a study of NSA, investigative reporter James Bamford says that the agency has similarly attempted to exploit a secret cipher. In 1957 NSA covertly sent William Friedman, a cryptologist, to meet his old friend Boris Hagelin, then a major supplier of cryptomachines. "Hagelin was asked to supply to NSA [with] details about various improvements and modifications . . . made to cipher machines his companies had supplied to other governments, including, especially, the member countries of NATO." Bamford was not able to learn whether Hagelin cooperated. But NSA's attempt to

Critics fear that the National Security Agency could decipher messages the senders think are secure.

build a trap door into an encryption system can only abet suspicions about its new ciphers.

Cryptography Goes Public

Over the last decade, NSA has had some success in its efforts to classify sensitive cryptographic research. Yet know-how has spread anyway. Mathematicians doing basic research with no thought of secrecy may find that their work has significant cryptographic implications. For instance, complexity theory examines problems not to solve them but to understand just how hard they really are. Since truly hard problems provide the basis for strong ciphers whose inner workings are open to inspection, complexity theory is one conduit through which cryptology has "gone public," in Kahn's words.

Today, all but the poorest nations secure high-level dispatches behind ciphers that can be broken only with the greatest difficulty. Intelligence agencies are often reduced to eavesdropping on unclassfied communications—and to studying who calls who rather than what they say. Intelligence agencies can also be foiled when their adversaries go low-tech: Iran sidesteps U.S. electronic espionage by sending sensitive information by hand.

But while governments are becoming more secure, individuals are becoming more vulnerable. The use of electronic mail and interactive cable TV is increasing, and the technology for tapping phone conversations is improving. In *The Rise of the Computer State*, *New York Times* reporter David Burnham writes that the high cost of paying people to listen to conversations may be as significant a deterrent to wiretaps as are legal strictures. Wiretaps are more widespread in low-wage countries such as the Soviet Union and India. This bodes ill, for voice-recognition technology is making automated wiretapping much easier. Computers can now screen calls and notify human agents only upon encountering designated words.

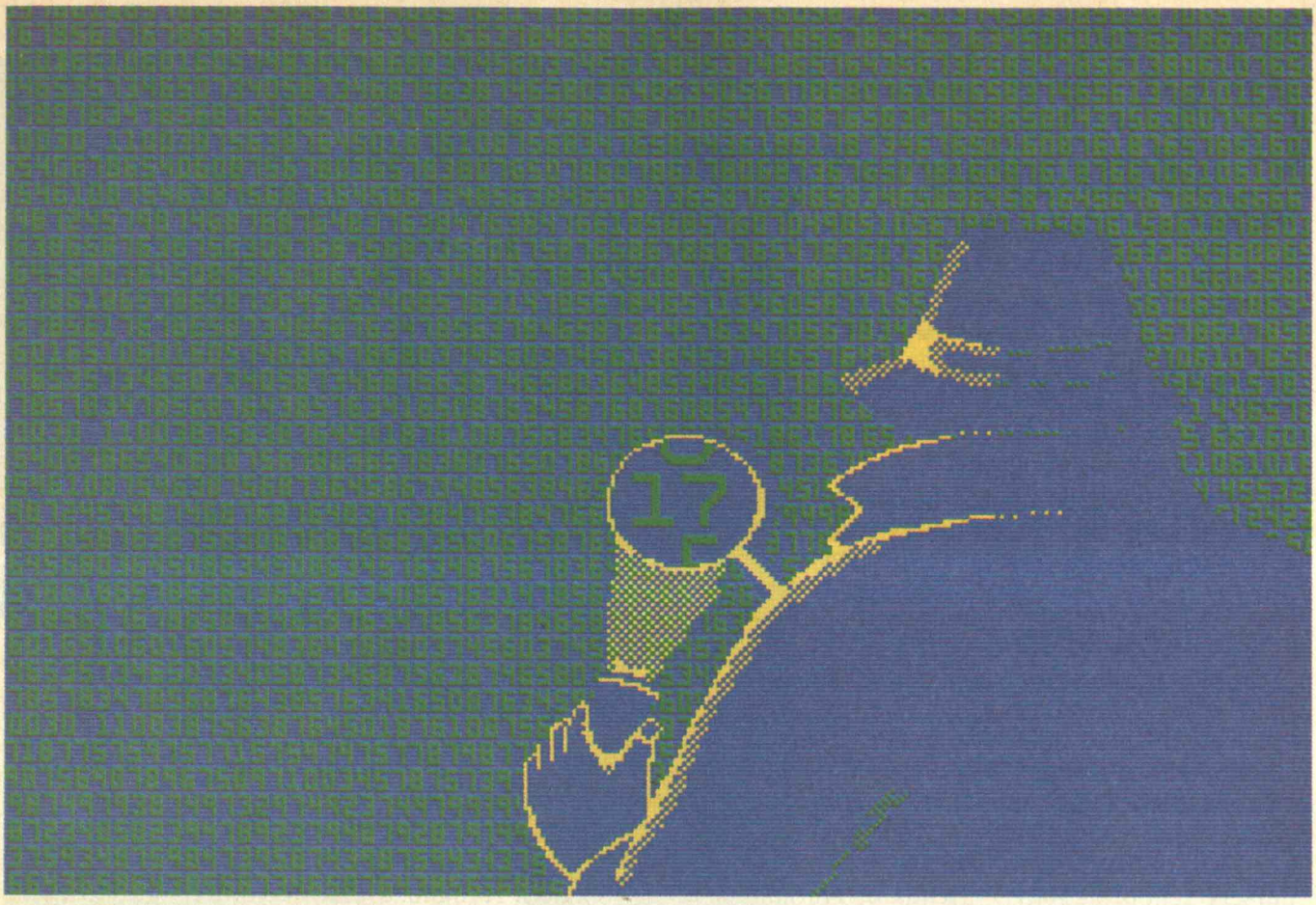
If used to establish a decentralized cryptosystem in the telecommunications network, public-key cryptology could go a long way toward preventing wiretaps. Public-key systems also enable users to sign messages with unforgeable electronic signatures. As Hellman puts it, such signatures are "like written signatures in that they're easily produced by the legitimate signer, easily recognized by any recipient, and yet impossible, from a practical point of view, to forge." To send messages using such a signature, you publish the decryption half of a two-part key. Only if a message is "signed" with the secret encryption half will decryption yield a meaningful cleartext.

Like conventional encryption systems, public-key systems can be based on a variety of algorithms. The best-known public-key algorithm is RSA (after Rivest, Shamir, and Adleman, the mathematicians who developed it). It is based on the difficulty of factoring prime numbers, a problem that mathematicians have been studying for thousands of years without fundamental progress. Factoring small numbers is simple: 40 can be factored into 10 and 4 (since $10 \times 4 = 40$) or into 20 and 2 (since $20 \times 2 = 40$). But factoring even slightly larger numbers is much harder. Factoring 5,893 (produced by multiplying 71 and 83) requires a number of trials. And because 71 and 83 are both prime numbers (divisible only by themselves and by 1), there's only a single answer.

To break an RSA-based cipher, you have to factor an enormous number, which can be hundreds of digits long, into so-called "cryptographic primes"—primes that can themselves be hundreds of digits long. Factoring the product, which is embedded in the public key, into its component primes—a process necessary to break the cipher—is effectively impossible, even with supercomputers. And no conceivable breakthroughs in computer technology will make any difference: factoring will remain hard until there is a breakthrough in number theory, a breakthrough that may not even be in the cards.

However, once a user obtains cryptographic primes—a number of sources, including the company marketing a cryptosystem, could provide them—only limited computer power is necessary to multiply them together and perform the other operations necessary to generate keys. Users could do this privately on microcomputers—without the aid of a centralized authority such as NSA.

Some mathematicians, especially within NSA's circle, point out that one public-key system was recently broken. This system was based on a variant of the "knapsack problem," which involves deter-



mining the best way to pack a collection of objects into a series of knapsacks. Yet the factoring problem is unrelated to the knapsack problem, so comparing systems based on the two is spurious. And public-key systems based on other problems may be even more secure than those based on the factoring problem.

Public-key cryptography is also criticized as being too slow for commercial applications. While public key is far slower than systems such as DES that were designed for speed, the criticism is misleading. For applications requiring high data-transmission rates, public-key systems could be hybridized with conventional high-speed cryptography. Such a hybridization would combine the best of both systems. Gus Simmonds of Sandia National Labs has described how a public-key system could be used to establish a temporary "session key." That key could be used with a conventional system to transmit any message, including a high-volume data stream of the sort required for video.

Finally, critics charge that public-key cryptography is impractical because NSA will never approve a public-key standard. This may be true. But the International Standards Organization, to which many European countries belong, also has the authority to legitimate systems, and it appears ready to give RSA its official seal of approval.

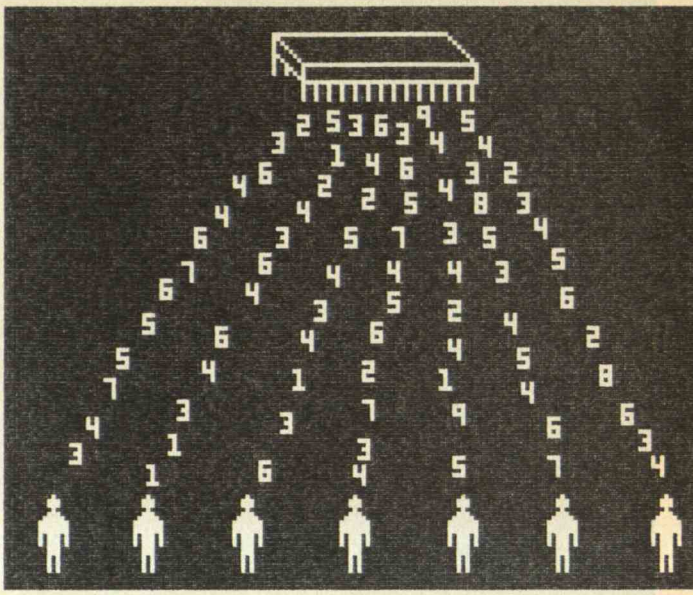
Taking on the Dossier Society

Each time we use a credit card to buy a book or rent a room, each time we pay a tax or receive a traffic ticket, each time we phone a friend, records are created and filed. Private credit agencies such as TRW Information Services and Equifax, Inc., collect this data into some 150 million dossiers, which are sold to customers including banks and employers. Proponents say that such record keeping makes the modern credit economy more efficient, and they are probably right. Yet this convenience exacts its price in a steady erosion of personal privacy. Our lives are encapsulated in credit-agency records. Moreover, those records are of dubious accuracy: data is hastily collected by low-paid workers and is often seriously flawed.

Government agencies ranging from the FBI to the Health and Human Services Department keep computerized files, too. In 1982, some 4,700 federal databases were maintained, an estimated 800 of which had been exempted from the provisions of national privacy law. The Reagan administration is a particularly eager advocate of databases, and of the "computer matching" that cross-checks them to reveal inconsistencies and fraud. ACLU studies indicate that inter-agency computer matching costs far more

Continued on page 66

Our lives are encapsulated in credit-agency records.



than it saves, but this hasn't slowed the Office of Management and Budget (OMB). In 1982 the OMB enacted guidelines under which agencies adopting computer-matching programs do not need to notify Congress or demonstrate the programs' cost-effectiveness. Today, the OMB sanctions such programs for records from, for example, welfare programs, the Veterans Administration, the IRS, and the Selective Service Administration. Even data about low-interest and farm loans are cross-checked.

Databanks and dossiers will soon come into even broader use. Alan Westin, Columbia University professor of public law and government, warns that the computerization of the home via cable TV, microcomputers, and other interactive systems will enable organizations to construct "master profiles" of citizens that make today's data collection seem like "nursery school activity." Means of automatically analyzing the data are improving, too. For example, the FBI is developing artificial intelligence systems capable of automatically searching for patterns in its massive databases.

As with wiretapping, laws can prevent abuses. The magazine *Advertising Age* recently surveyed telemarketing regulations and restrictions of access to state agencies' mailing lists. The magazine noted that the "right to privacy may be a barrier to business." In other words, some laws to protect privacy do appear to have an effect. Unfortunately, though, a changing political climate could lead to repeal of these laws, or simply to a lack of proper enforcement. Robert E. Smith, editor of the Washington-based *Privacy Journal*, reports that the Reagan administration has failed to adequately enforce existing federal privacy law.

Encryption technology also has a part to play in protecting individual privacy. In the October 1985 issue of the *Communications of the Association of Computing Machinery*, David Chaum, a cryptologist at the Center for Mathematics and Computer Science in Amsterdam, suggested means of preventing dossier construction while still supporting an advanced electronic economy. Taking public key as his foundation, Chaum has developed techniques for substituting "digital pseudonyms" for the social security numbers, driver's license numbers, and other personal identifiers that make computer matching and dossier generation possible. Simply put, every "check" written in Chaum's economy would be like those on the old TV show "The Millionaire": you could cash it but you couldn't find out who wrote it. People would not need to identify themselves to prove that they have the necessary funds, the right degree, or a crime record free of rape convictions.

Chaum recognizes that institutions have a legitimate need for certain data. For example, when you open an account with the telephone company, it has to find out whether you pay your bills. Under the current regime, it does so through credit agencies. As it provides you service, the phone company provides further information to these agencies, and your dossier grows. In Chaum's approach you would begin your relations with the phone company by establishing a pseudonym—a key. The phone company would withdraw funds from a bank account identified only by this pseudonym. The company would get its money, but not your name. Other institutions could reference the same account—perhaps to deposit money or check the balance—but they'd all use different pseudonyms. As a result, you'd have the same anonymity people had in the old cash economy. And while the mathematics behind the system are complex, transactions wouldn't have to be. Small "card computers" would do the bulk of the work. Such computers, resembling credit cards, would contain microprocessors to generate and manipulate digital pseudonyms.

Chaum's approach won't be adopted in the near future, and some consider it just another crazy technocratic scheme. But even if it isn't workable, alternatives could surely be designed to achieve similar ends. What's crucial is the view that individuals shouldn't have to trust large organizations any more than those organizations trust individuals.

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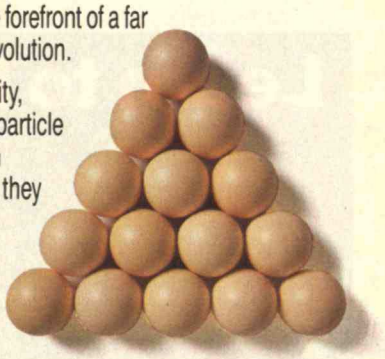

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The ACLU's Privacy and Technology Project is making a major effort to promote this perspective. Jerry Berman of the project would like to see a congressional committee formed to study security policy and to recommend legislation protecting civilian as well as government privacy—in particular a statute to modify NSDD-145. Legislation taking the first step, sponsored by Rep. Dan Glickman (D-Kan.), has already been reported to the full House. The bill, HR 2889, would create a civilian counterpart to the committee established by NSDD-145 and would put civilian information and communications-security policy under civilian control. HR 2889 is only a tentative beginning. It doesn't take the crucial step of abolishing the concept of unclassified national-security information as the basis of government policy, and it has a long way to go before adoption. NSA will use its power to oppose the enactment of such legislative restraints.

Walter Deely, formerly of NSA, told the House Committee on Science and Technology that "cryptography, like nuclear weaponry, is the government's business first and foremost." He fears "provision of cryptographic information to the other side . . . [by] putting cryptography in the public domain." Mr. Deeley has retired, but his views have not.

Donald Latham, assistant secretary of defense for command, control, communications, and intelligence, has said that "there's still a fair amount of invention needed" before the "computer security problem" is solved. Most cryptographers would agree. The question is whether that invention will be directed toward protecting only national security or the privacy of the individual as well. Once adopted, either technological approach will reinforce the values that created it. □

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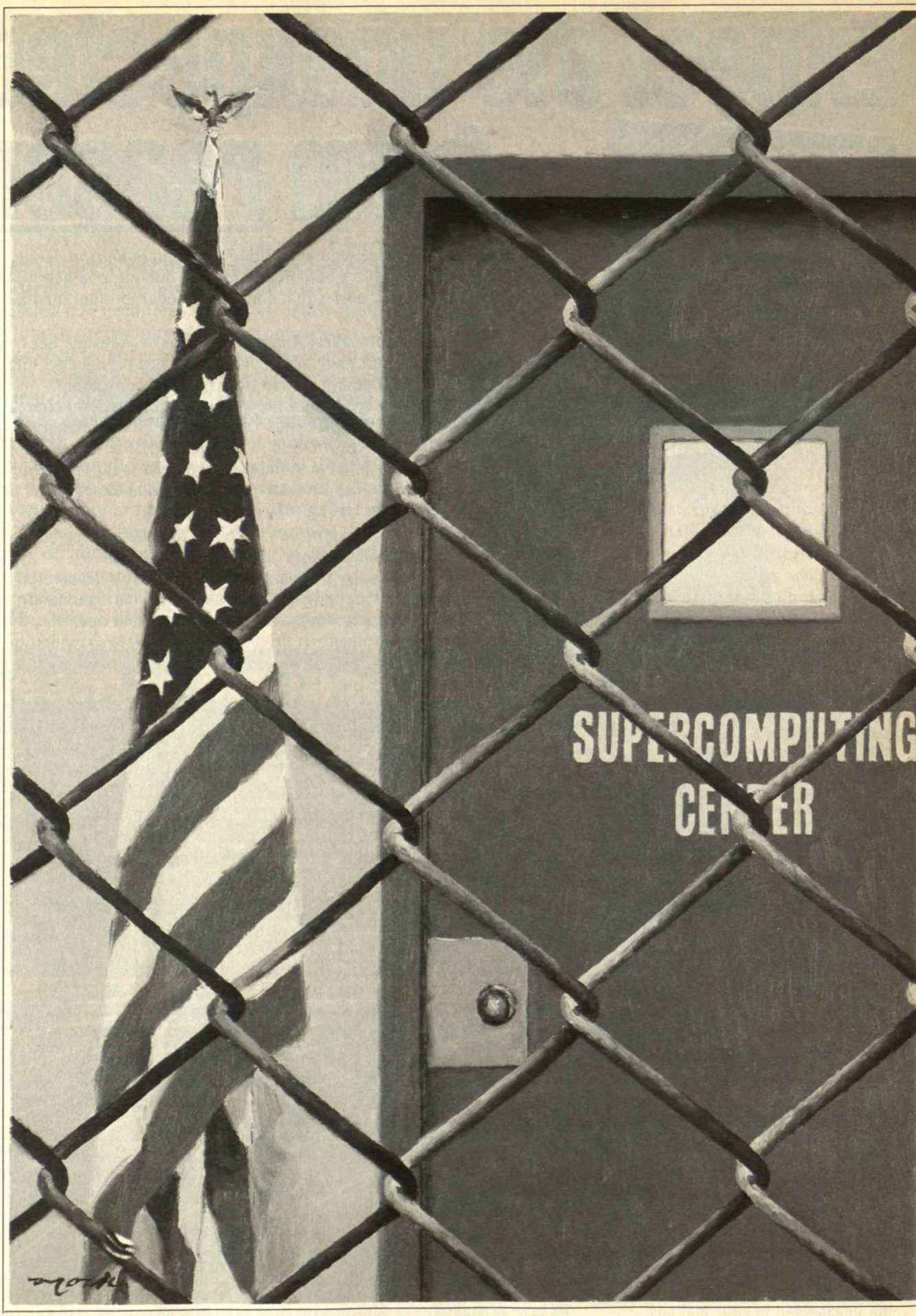
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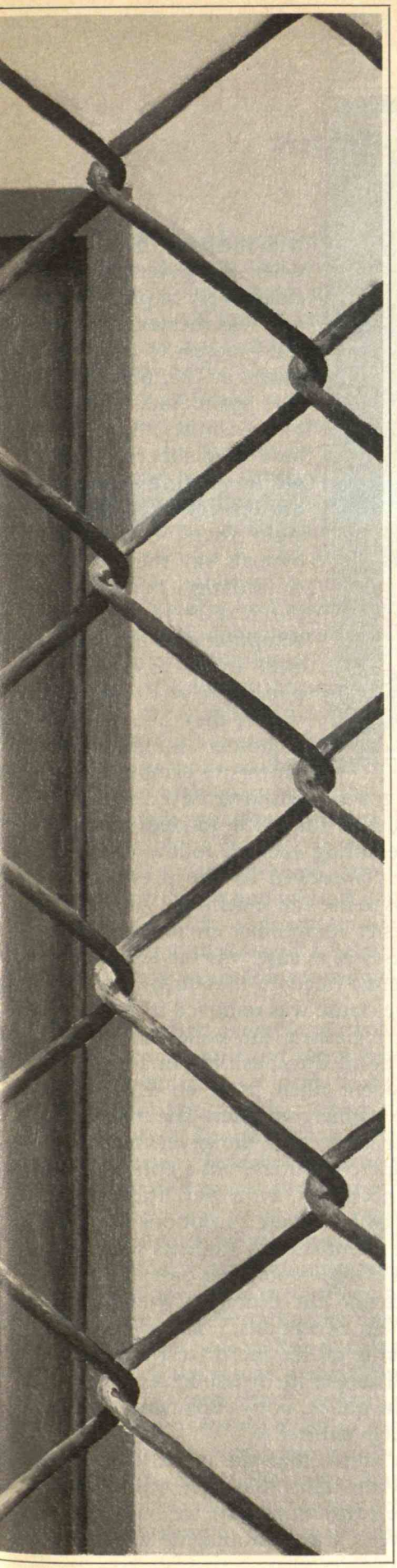


The Pentagon wants to ban Soviet use of supercomputers on U.S. campuses. Universities say the threat to national security is small and that the ban will hurt U.S. science.

Supercomputers and the Soviets

BY ANDREW C. REVKIN

THERE is a new contestant in the arms race: the supercomputer. These potent machines are rated not in megatons but in "megaflops"—a megaflop being 1 million calculations per second. The strategic value of supercomputers lies in their ability to simulate, to analyze, to crunch numbers. Among other things, supercomputers are being used by the U.S. military to break codes, configure nuclear weapons, and model new aircraft shapes. They are also an integral part of U.S. plans for a ballistic-missile defense.

This race is no contest. The United States has supercomputers and the Soviets don't. The Pentagon would like to keep it that way. "We think [the Soviets] have a genuine crisis in their military-industrial complex because they don't have the computing power," says Stephen Bryen, deputy assistant secretary of defense for economic, trade, and security policy. The Pentagon has convinced the Coordinating Committee for Export Controls (COCOM), the West's international organization for technology transfer, to prohibit the sale of supercomputers to the Communist bloc. The Pentagon also wants to keep anyone from the Soviet bloc from using supercomputers located in the West. The Defense Department is therefore threatening to ban Soviet access to supercomputers on U.S. campuses, and is asking our allies to restrict the Soviets' use of their

ILLUSTRATIONS: PAUL MOCK

machines as well. Yet many scientists maintain that the risk that Soviet scientists will do clandestine research on academic supercomputers is small. A more pressing threat, many say, comes from the growing number of commercial supercomputing centers, which guarantee their customers complete anonymity.

Restrictions Threaten U.S. Science

Supercomputers at the Lawrence Livermore National Laboratory, the National Security Agency, and other government installations are carefully guarded. But a growing number of these machines—there are around 160 worldwide—are installed in the basements of corporate and university laboratories in the United States, Canada, and the Middle East, Western Europe, and Japan. The largest single spurt in civilian computing power began last year when the National Science Foundation (NSF) awarded funding to five U.S. universities to establish their own supercomputing centers. Most of these machines are the products of Cray Research and Control Data Corp., both American firms. However, three Japanese companies have entered the market with their own supercomputers, and other firms will soon join in with a variety of Crayettes, or "superminis"—somewhat smaller machines that deliver more speed per unit of cost. Ultimately, there will be another generation of supercomputers.

Enlisting the help of the Departments of Commerce and State, the Pentagon has acted quickly to add clauses to export licenses prohibiting Soviet use of U.S.-made supercomputers. An agreement was also worked out with Japan stipulating that it would sell its supercomputers only to buyers that would keep them off limits to the Soviets. Our allies complained, says Bryen, but that was nothing compared with the howl that went up when the government decided to try to plug what it said was the next potential leak—access to supercomputers at U.S. universities.

A sprinkling of Soviet-bloc scientists and students have used supercomputers while visiting American universities over the past eight years. Government officials say there is a serious danger that such visitors will secretly use computer time for research with military value. The problem will only get worse, they say, as supercomputers spread to more university campuses.

Last year, the government inserted a clause in the contracts for the first four NSF-funded supercomputing centers requiring each to follow "whatever national policy is approved by the president" on Soviet-bloc access to the new machines. With a single voice, the university community cried foul, arguing that the risk of Soviet misuse was far less than the damage to academic freedom that such restrictions would inflict. The clause was removed from the contracts, but after reviewing the policy the Defense Department has decided to push for an airtight rule that no non-resident alien from an Eastern-bloc country may use a supercomputer. The universities, backed into a corner because the government funds most campus supercomputers, have conceded that restrictions are necessary. However, they are still fighting for the right to make exceptions for "bona fide" Soviet-bloc scientists and students who would use tiny amounts of supercomputer time. Still, many observers predict that the Pentagon will hold firm on a policy of "no exceptions." The Defense Department is banking on the fact that a sympathetic White House will cooperate by issuing a presidential order invoking the policy, or by convincing the State Department to help enforce it.

Some officials admit that the crackdown is designed to assure our allies that they are not being forced to impose restrictions that we have not imposed on ourselves. "Can you imagine what it'll be

ANDREW C. REVKIN is a staff writer at the Los Angeles Times *and the 1986 winner of the AAAS-Westinghouse Science Journalism Award.*

Scientists are concerned that as the use of supercomputers grows, restrictions on international dialogue will also spread.

like in the Western European countries," Bryen asks, "which are closer to the Soviet Union, which have more of their people running around all the time, and which have Communists in their parliaments? It could cause a lot of trouble. The second largest party in Italy is the Communist party, and yet we have a Cray in [Italy] with these controls. Now if we don't keep faith, if we don't have these controls here, it'll be the Russian Cray."

"That may be a strategy, but it's not justice," counters Thomas Everhart, chancellor of the University of Illinois at Urbana-Champaign, home of one of the new NSF-funded supercomputing centers. He and other university representatives say that a blanket prohibition on Eastern-bloc access will undermine open academic research by making unclassified facilities off-limits to some students. These representatives also say the policy will hurt American science in areas where the United States benefits greatly from East-West dialogue.

Progress in many scientific disciplines—from meteorology to high-energy physics—has always been linked to international cooperation that has included the Eastern bloc. Weather forecasting and climate studies rely on data gathered around the world and processed on supercomputers. Right now, in fact, a European scientific consortium actually has more-advanced computers—and a better track record on medium-range weather forecasting—than the United States.

Perhaps the best example of a field that needs both advanced computers and input from the Soviets is thermonuclear fusion. Florida State University has a supercomputing effort that is partially funded by the Department of Energy and is frequently used for fusion research. Joseph Lannutti, who directs the supercomputing center there, says, "In fusion, the Russians are ahead of us. If we refuse them, it's like cutting off your nose to spite your face."

"It is critical to maintain openness," says Kenneth Wilson, a Nobel laureate in physics who directs the NSF-funded supercomputing center at Cornell. "You only have to go to Russia to see the devastating effects of a closed research environment." If blanket restrictions go into effect, he says, "there will certainly be a very strong reaction because of the importance of maintaining access to Soviet scientists—especially in areas like high-energy physics and plasma physics." Many scientists are also concerned that as supercomputing spreads through a growing range of scientific disciplines, restrictions on international dialogue will spread as well. The technology is finding new uses every year. Florida State's Lannutti also fears that the new policy will prevent universities with supercomputers from hosting any leading Eastern-bloc scientists.

Few Abuses Uncovered

Academics and government officials agree that the Eastern bloc has nothing even close to the power of the supercomputers that are already approaching old age in the West—the venerable Cray 1 series and Control Data's Cyber 205. These models are frequently called "Cray-class" computers because they will soon no longer be supercomputers. That title is reserved for the next generation that is always around the corner. American and Japanese manufacturers are already refining supercomputers that will move well into the "gigaflop" range, performing billions of operations per second. Meanwhile, scientists attending an international conference in Florida last December jokingly referred to the Soviets' only publicly known effort to produce a supercomputer as "one of everything joined together."

No one doubts that the Soviet-bloc effort to acquire advanced Western technology is well organized, well budgeted, and well manned. According to U.S. government reports, technology acquisition is a $1.4 billion Soviet industry. A 1980 Congressional Research Service study estimated that the East German intelligence service alone had placed 500 agents throughout West German industry—including German offices of IBM, Intel, and Control Data. According to a 1985 report published by the CIA, the Military Industrial Commission, or VPK, coordinates the Soviet effort, assigning tasks to the KGB and other government agencies, including the Soviet Academy of Sciences. The targets include more than 60 American universities, including all those with supercomputers. The Soviet "collection agencies," as the report calls them, reportedly bring in an annual haul of 100,000 documents and up to 10,000 pieces of hardware.

But American intelligence has turned up few concrete examples of abuses by Soviet scientists and exchange students. In fact, the CIA report concludes that the Soviet Academy of Sciences is "involved principally in overt collection of information for nondefense industries." In 1982 Bobby Inman, then

A powerful computer in an academic setting is always being watched.

deputy director of the CIA, testified at a Senate hearing that intelligence services gather 70 percent of the Western technology acquired by the Soviet bloc. Another 20 to 30 percent comes from legal purchases and open publications, and "only a small percentage . . . comes from the direct technical exchanges conducted by scientists and students."

Many members of the American scientific community say they are well aware that Soviet scientists often have a "hidden agenda" or a "shopping list." But no one among a wide range of scientists interviewed expressed knowledge of a Soviet scientist who had done anything criminal while on exchange. Harry Rositzke, a CIA specialist on the KGB for 25 years and author of *KGB: The Eyes of Russia,* says, "The last thing the Soviets would do, with all their other means of doing these things, would be to use an accredited scientist for espionage."

This record may partly result from the careful screening process that the U.S. government applies to prospective visitors from the far side of the Iron Curtain. The screening mechanism is COMEX, the Committee on Exchanges, made up of representatives from intelligence agencies and the Departments of State and Defense. COMEX now also confers several times a year with a civilian advisory board that includes representatives from academia and business. This interagency panel has screened every Soviet scientist who has wanted to visit the United States since scholarly exchanges between the two countries began in 1958. COMEX gives its opinion—recommending that a visa be approved or denied, or that the itinerary of a prospective visitor be modified—to the State Department, which has the final say.

The Pentagon has unearthed only one specific example of suspicious activity by a Soviet scientist working with U.S. supercomputers: the case of Vladimir Alexandrov. For more than 100 hours over seven months in 1978, this Soviet physicist-turned-climate-modeler ran a Cray 1A supercomputer at the National Center for Atmospheric Research (NCAR) in Boulder, Colo. He also worked on an NCAR Cray in 1980 through a remote link from Oregon State University.

Larry Gates, an atmospheric scientist at Oregon State who worked closely with Alexandrov, says that the level of access afforded Alexandrov was "an aberration": he was using the NCAR computers when the system was underutilized. The incident "probably opened our eyes that we should be a little careful," Gates says. "But he made no improper, unscientific, or non-mainline use." Not one out of a score of scientists who worked closely with Alexandrov says he ever did anything suspicious.

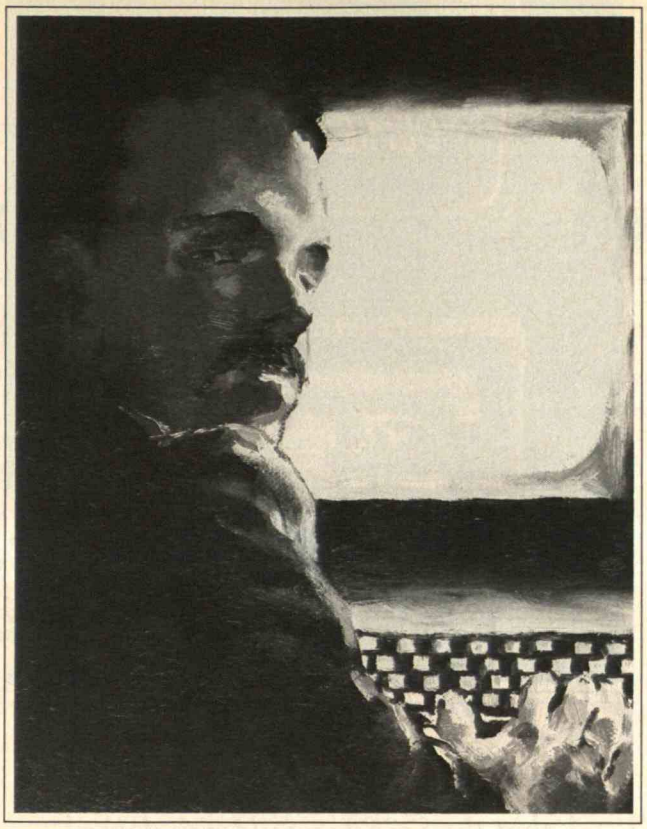
Despite these assurances, American intelligence agencies started to worry about Alexandrov. In January 1985, on his last visit to the United States, officials marked his visa with the restriction that he should have no "direct or indirect access to supercomputers." This type of visa restriction is the mechanism the U.S. government probably will use to enforce its policy prohibiting Eastern-bloc access to supercomputers. (Alexandrov, who had become a prominent Soviet authority on nuclear winter, disappeared last year after attending an anti-nuclear conference in Cordoba, Spain. It is unclear whether he defected, was kidnapped, or was murdered.)

Many of Alexandrov's former American colleagues maintain that visa restrictions, often called "the Alexandrov solution," are unenforceable. Starley Thompson, at NCAR, says, "Once a guy's on our property, he's like anyone else, with free access to plunk around and do whatever he wants to do. You can't just look over his shoulder and see what he's doing at all times. Suppose Alexandrov came here last January [1985], as he did, and he sat down at the terminal and started doing things," Thompson says. "What am I supposed to do, make a flying tackle, call 911, and say I've got a spy in the hall?"

Misuse Would Be Difficult

Many observers also doubt that the Soviet Union would be willing to risk doing military research on foreign soil in the first place. Harry Rositzke maintains that no amount of tempting hardware would convince the Soviets to do their most sensitive computing "behind enemy lines." John Connolly, director of NSF's Office of Advanced Scientific Computing, says, "If you were an American bomb designer and the Russians had a good machine, would you go over and design your bomb there? No way. You don't know who's tapping into the files."

Another reason for the Soviets to avoid such risks is that their own computers—although orders of magnitude slower than American machines—are still fine for most projects. Doyle Knight, a professor of mechanical and aerospace engineering at Rutgers and one of the directors of the NSF-funded Con-



sortium for Scientific Computing, explains: "Let's say one was concerned about an unauthorized user sneaking an hour of supercomputer time in six months," he speculates. "Whoever this person is, if he's trying to sneak onto a supercomputer, he undoubtedly already has a minicomputer." A Cyber 205 supercomputer is only 100 to 200 times faster than, for example, a VAX minicomputer, he says. "This would be one of the most stupid risks to take when he could have done it in a hundred hours on a VAX back in his own country."

Even if Eastern-bloc scientists could get large blocks of time on academic supercomputers, it is highly unlikely that they would be able to use the time for clandestine research. Dan Anderson, a computer programmer who has helped manage NCAR's Crays since they were installed, says that a powerful computer in an academic setting is always being watched. "When you start using large amounts of computer time, everyone becomes immediately aware of it, particularly the other scientists," he says. "Scientists are a lovely bunch of people, a gentle lot. The moment one of these guys sees anybody else on the computer, he's bitching and moaning, saying, 'That guy shouldn't be on there, he's doing dumb science.' " Furthermore, computer time at the federally funded supercomputing centers, as well as at other academic centers such as NCAR, is allotted after a peer-review process: projects are judged on their scientific value both before and after they are run. Cornell's Kenneth Wilson says, "If you get through the review process and are awarded time, you have to use it effectively. If you don't, you'll find that you're not getting more time."

Sidney Fernbach, who spent 27 years designing and using the computing facilities at Lawrence Livermore Laboratory and is now chair of the Institute of Electrical and Electronic Engineering committee on supercomputing, says that it would be virtually impossible to write a program that would yield results without many adjustments. "With something like planning a bomb, you don't know quite what you want it to do until you experiment," he says. "You put in all kinds of parameters and get results. Many of these codes are used for a year or so before you really learn how to put in the optimum types of materials and proper radii to get a result that you're looking for." A Soviet scientist would hardly be able to do this amount of "tweaking" without being spotted.

"I was involved with these things for years and I know how difficult it is," Fernbach says. "As a matter of fact, some people never get any good answers at all—even with a supercomputer." And of course there are the bugs—the inevitable unanticipated glitches in the program that must be fixed one by one. "If a code is of decent size and is of any importance and really requires a supercomputer, it could take half a year to a year just to debug the thing," Fernbach says. "And what have [the Soviets] debugged it on, a PC? It just can't be done."

Moreover, before a program can run on a supercomputer, it has to be translated from the language it was written in—usually a human-readable programming language such as Fortran—to machine language, a numerical code tailored to the capabilities of a particular machine. This is done by another piece of software called a compiler. The compiled program is then fed into the computer and executed. "Since the Soviets don't have Crays, they can't just bring over the executable program [in machine language] and immediately load it onto the Cray and run it," says Starley Thompson, at NCAR. "You've got to have it in a form that a human could look at and say 'Ah, this looks interesting. This looks like a bomb code; it doesn't look like aerosol dispersion to me.' "

"I think the whole thing is ridiculous," Fernbach says. "We claim here in this country that we need half a dozen supercomputers to do nuclear weapons

research, and then we're denying a Soviet five minutes. If they can do it in five minutes, more power to them."

Commercial Centers Pose a Greater Threat

Many computer experts say there is a much greater risk of Soviet intrusion at commercial centers than at academic supercomputer centers. Almost anyone can set up an account at the commercial centers, "dial in" or send in a tape, and run codes in guaranteed secrecy.

One example is the Institute for Computational Studies, a nonprofit company set up to manage the Cyber 205 that Colorado State University (CSU) bought in 1982. According to Daniel Pryor, senior staff scientist, CSU plans to pay for the machine, which was acquired without NSF funding, by selling time to commercial clients ranging from large oil companies to an engineering consulting firm in Fort Collins with 10 employees.

Pryor says there is little ICS could do if Soviet agents were to create a dummy corporation, set up an account, and run codes for whatever they wanted. "It would be very easy once you have time on the machine designated for one purpose to do something else," Pryor says. "What you see is a job sitting in the machine, crunching away. You have no idea what it's doing." The system is specifically designed to ensure customers' anonymity and privacy.

The situation is the same at Scientific Information Systems (SIS), an offshoot of Control Data that sells time on both a Cyber 205 and a Cray 1. Stan Gardner, manager of supercomputing marketing for SIS, says that his firm does business only with "countries that are on the government's approved list," including Canada, Mexico, Britain, France, Spain, West Germany, Italy, Australia, and New Zealand. Yet he readily concedes that there would be no way for SIS to know if a company in, say, West Germany were merely a front for Soviet-bloc intelligence: "Any person with a standard amount of corporate credit established with any firm around can open an account," Gardner says. "I don't know what each company does. If I knew that, we could be busting some security." Since the Pentagon has recently estimated that the Soviet bloc has set up some 300 dummy corporations just to funnel technology eastward, this situation seems ripe for abuse. The Defense Department's Stephen Bryen admits that potential misuse of the commercial centers is a concern. He claims that "we have ways to work that problem" but refuses to give details.

Many observers doubt that the Soviets would risk doing military research on foreign soil anyway.

Donald Goldstein has seen the issue of supercomputer security from both the Pentagon and the private sector. Formerly principal director of the Pentagon's Office of Trade Security Policy, he is now president of System Planning Corp. International, a firm that helps lead American and foreign companies through the maze of licenses, clearances, and conditions that surround the export of technology. "It's obviously a difficult matter to strike a balance between two principles that are antagonistic," Goldstein says. "But it's also equally clear that there's a need to come up with a policy that accommodates both."

The supercomputer issue "will probably settle down, but others will open up in other places," he says. "A few years ago, we were very concerned with the proliferation of small microprocessor-based personal computers. Now the Soviet Union can buy 20,000 small Japanese PCs in one fell swoop. That never could have happened just a few years ago. But the technology has moved on. The names change, the issues change, but the basic underlying tension between restriction of technology and proliferation of technology will remain." □

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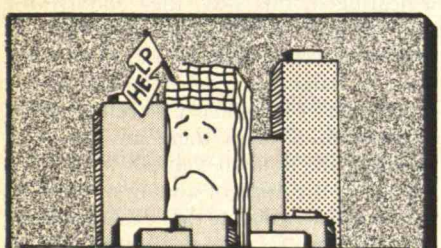

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Technological Limits, and Ornament Through the Ages

Technological Limits

The Whale and the Reactor
by Langdon Winner
University of Chicago Press, $17.50

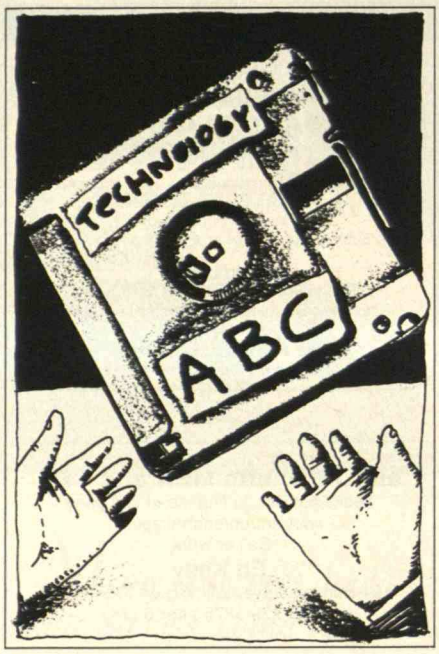
Reviewed by Christopher Lasch

Too much talk about technology assumes that it has a life of its own, that new technologies come into being because they are shown to be more efficient than the ones they replace, and that technological progress therefore rolls on relentlessly. Only when new technologies are already in place does our society worry about their social and political "side effects," usually by assigning various experts to study the costs and benefits of changes that have already occurred.

In fact, technologies are political from the beginning. Sometimes they are political by design, as when employers try to reduce their dependence on skilled labor by subdividing the labor process and introducing new machinery. Sometimes they are only indirectly political, as when well-meaning reformers in the twenties and thirties tried to persuade farmers to adopt "scientific" methods and to invest in machinery that could profitably be used only on large holdings of land. These innovations drove small farmers out of business. Today the use of sophisticated networks of information retrieval is likely to have similar effects on a broad range of industries, since only giant firms can afford to install these technologies and take full advantage of them. Yet we persist in talking as if technologies are neutral instruments that can be used for a variety of ends—as if the mechanization of agriculture, for instance, is perfectly compatible with an agricultural policy that claims, as ours still officially does, to preserve the family farm.

Most of the technologies that our society adopts by their very nature promote large-scale organization, bureaucracy, and the centralization of economic and political power. It makes no sense to pretend that these technologies can be used for good or bad purposes that depend on social priorities. They already embody choices—the wrong ones, if you think political power should be distributed as widely as possible.

Langdon Winner, professor of political science at Rensselaer Polytechnic Institute, showed an ability to think clearly about



such matters in his first book, *Autonomous Technology*. His new book, *The Whale and the Reactor: A Search for Limits in an Age of High Technology*, consists of essays united by a theme that emerges gradually. In order to understand the nature of technology, according to Winner, we need to clean up our language. The current terms of debate have misleading implications that need to be exposed and criticized.

Take the debate about risk assessment—the subject of one of Winner's best essays. By substituting "risk" for the more straightforward concept of "danger," current debates about environmental policy, say, shift the burden of proof to those who resist technological innovation. Risk assessment takes the benefits of a given technology for granted, invariably describing them in a loose, mindlessly optimistic fashion, and subjects only the social costs to minute and ultimately inconclusive scrutiny. This intricate, painstaking scientific investigation replaces common sense with expert opinion and usually leads only to the conclusion that experts can't agree about the risks. In view of their indecision, the rest of us can hardly stand in the way of progress.

Cost-benefit debates imply that those who worry about risks are nervous Nellies (as Lyndon Johnson used to refer to opponents of the Vietnam War) unwilling to step boldly into the future. According to anthropologist Mary Douglas and political scientist Aaron Wildavsky, people who take risks seriously suffer from obsessive anxiety. They have "cold feet," in the language of an ad for Mobil Oil, which concludes: "Taking risks: it's the best way to keep America rolling."

In another essay, Winner debunks the "information revolution"—the utopian descriptions of a society in which computers will eliminate drudgery, broaden political participation, and level invidious social distinctions. Such claims, Winner argues, ignore both historical experience and reasonable expectations about the future. In the past, revolutions have changed the distribution of power, generated new ideas, and advanced clearly defined political goals. They did not occur simply because new technologies came into being. Instead of revolutionizing our society, computers in themselves will only reinforce existing inequalities. The most reliable studies project a great increase in the number of menial jobs, not a society where most boring jobs can be done by machines.

Winner does not direct his argument solely or even primarily toward technological optimists. He wants to show how even critics of technology find themselves trapped in the current terms of the debate and forced to argue on their adversaries' ground—for instance, by tempering moral and political indictments of technology with ostensibly hard-headed arguments about costs and benefits. Hoping to gain a hearing in this way, they endorse the premise that everything has its price, and that the prices of clean air and clean water must be balanced against the unspecified advantages of unchecked technological develoment. Nor is there any point in dragging in "human values" at the last minute in the hope of adding moral considerations to a debate that excludes them. The concept of values has become empty and innocuous—a way of avoiding politically charged issues such as social justice, the abuse of power, and, in Winner's words, the "fate of the planet and its suffering masses."

Winner does not exempt from criticism fervent ecologists who deify nature and want to make it the ultimate arbiter in debates about technology. This part of his argument needs to be fleshed out a bit. Most readers will not grasp, without further explanation, the truth of his obser-

ILLUSTRATIONS: EUGENE YELCHIN

Many of these authors imply that the belief in magic has not died out in the twentieth century.

vation that the "ecological model presents a mirror-image of advanced industrial society." But his general point is clear: that the only reliable standard by which to judge technology is neither "progress" on the one hand nor "nature" on the other but politics. The question is what kind of society we think we are and want to become. If we value democracy, we need to reconsider our commitment to unlimited technological development.

CHRISTOPHER LASCH is Watson Professor of History and chairman of the department at the University of Rochester. His most recent book is The Minimal Self *(Norton, 1984).*

Progress as Panacea

Imagining Tomorrow
edited by Joseph J. Corn
M.I.T. Press, $17.50

Reviewed by Karen Rosenberg

The collection of essays called *Imagining Tomorrow*, edited by Joseph J. Corn, is based on an imaginative premise: that many of us are curious how past Americans envisioned the technological future, and how those visions both reflected and shaped our culture. Most of these essays are by historians and concern dreamers and their inflated hopes. Although the historians fail to say how many people—and which segments of society—accepted the buoyant predictions of technological dreamers, these scholars help reveal the origins of utopian thinking.

For example, Jeffrey Meikle hazards a provocative guess at why the horizontal, flowing design style called streamlining became a hallmark of modern styling—for products from table radios to electric razors. He postulates that when it originated in the mid-1930s, "streamlined design reflected the desire of Americans for smooth, frictionless flight into a utopian future in which rounded vehicles, machines, and architecture would provide a protective, uncomplicated, harmonious environment closed off from the sorts of social and economic dislocations that marked the Depression." The new designs gained in evocative power from their association with plastics, the "miracle material." And the new profession of industrial design enhanced the magical aura of streamlined plastics, as designers known as "wizards of gloss" gained a reputation for reviving floundering sales.

In her article on skyscraper utopias, Carol Willis contends that by the 1920s, tall buildings had become patriotic symbols of American prestige, and that architects had acquired the status of dominant oracles of the day. Many architects predicted that aerial highways would link skyscrapers spaced at regular intervals, while others dreamt of clusters of skyscrapers towering over urban vistas. Many dreamers' drawings, reproduced in *Imagining Tomorrow*, could serve as sets for a sci-fi movie—and in fact Hollywood did borrow one fantasy for the 1930 film *Just Imagine*, called the "first science-fiction musical." Although few of the architects' fantasies were realized, their guiding principle of a rationally planned and zoned urban environment is an influential legacy.

Many of these authors imply what the American social theorist Thorstein Veblen stated emphatically: that the belief in magic has not died out in the twentieth century. Like his contemporary Sigmund Freud, Veblen was preoccupied with the irrational in modern life. Tweaking the noses of those who smugly believed in progress, he looked to primitive cultures for analogies to contemporary rituals.

Our society has often disguised the irrational and utopian nature of its hopes for technology with quasi-scientific terminology, and the historians of *Imagining Tomorrow*, trained like literary critics, look for old myths in this new guise. For example, Nancy Knight sees the revival of alchemical dreams in the claim of a Cedar Rapids man that he used newly discovered x-rays to change "a cheap piece of metal worth about 13¢ to $153 worth of gold." Steven Del Sesto catches echoes of patent-medicine hucksters in physicist William Laurence's 1946 prediction that tagged atoms, acting as tracers, would make possible cures for cancer and arthritis as well as diseases of the heart and kidneys. Laurence also believed that atomic medicine would enable humans to postpone the aging process—a fantasy that suggests to Del Sesto the ancient longing for the fountain of youth. As these examples show, superstitions are remarkably resilient and we cannot pride ourselves in having shed them entirely.

The Bible, too, has shaped our society's view of technology. Carolyn Marvin writes that one observer at the 1893 World's Fair compared the searchlights to "the holy light from the rapt gaze of a saint or Faith's white, pointing finger." Jeffrey Meikle hears the cadences of the Gospels in a 1935 *Business Week* article on plastic that speaks of "the mysterious ways in which chemical processes move, their wonders to perform." According to Joseph Corn, flight was considered a miracle early in the century, and aviation was thought to be a holy cause that promised a world in which all men would be brothers. The wireless evoked similar hopes that increased communication would initiate world peace. No wonder people expect miracles from technology when it is described in such religious terms.

Optimistic predictions have been the stock in trade of the popular media since the end of the nineteenth century, when science journalism became a pawn in newspaper circulation wars. According to Susan Douglas, "The grander the prophecy, the more dramatic (and beneficial) the changes envisioned, the better; caution did not sell newspapers."

Of course, journalists have hardly been alone in hawking technology; manufacturers have also put promises about the technological future to use for their profit. Architectural historian Folke Kihlstedt

Brolin terms Modernism elitist in its stern moral rejection of the simple pleasures of ornamentation.

writes that in the 1930s, businesses anxious to stimulate buying habits broken by the Depression created the consumer orientation of the 1939-40 New York World's Fair. Its Town of Tomorrow, with a utopia of conveniences, was also seen as an answer to the appeal of communism and the threat of fascism. The fair would "demonstrate an American Way of Living" and show science to be the most powerful social force, according to its organizers.

The promise that technology can render politics obsolete often goes hand in hand with the unquestioning belief in its healing powers. These essays point to Americans' desire to avoid, by constructing a new material or machine, the slow and frustrating process of changing attitudes and habits. Nancy Knight points out that some doctors thought that x-rays would obviate the need for preventive medicine and a better public-health system. Other prophets declared that the abundance soon to be created by nuclear energy, nuclear-based agriculture, and plastics would eliminate competition for goods and resources. Yet those who promised these results actually distracted society from developing alternative sources of energy and pursuing other efforts to narrow the gap between rich and poor.

Why does U.S. history keep producing supposed panaceas that don't pan out? Perhaps because when free land in the West disappeared, technology acquired the status of a new frontier. In the late nineteenth century, the influential American historian Frederick Jackson Turner postulated that the frontier functioned as a safety valve by offering an escape from scarcity and social conflict. He spoke in resonant, even mythic terms of the rejuvenation of humanity on wild, green, free land. History suggests that it is often easier to substitute one myth for another than to alter a whole structure of hopes and expectations. The dream of the plentiful garden dies hard.

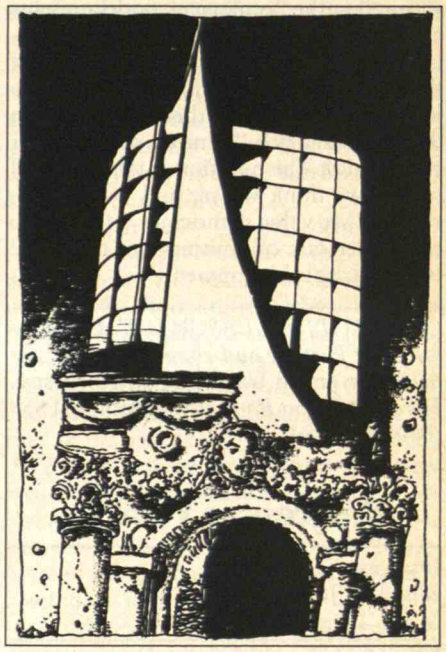
KAREN ROSENBERG writes widely on politics and culture.

Ornament Through the Ages

Flight of Fancy
by Brent C. Brolin
St. Martin's Press, $30

Reviewed by Thomas Frick

According to Brent C. Brolin, humanity has always had an instinctual need to ornament everything, from handheld implements to huge cathedrals. In *Flight of Fancy*, Brolin makes an ambitious attempt to explain and critique the Modernist movement in architecture and the decorative arts by placing it against the history of ornamentation from antiquity to the present day. Judged from this standpoint, the clean lines, spare forms, and undecorated planes of Modernist structures, which came into prominence during the 1920s with the Bauhaus school, are a complete aberration in the history of taste. Brolin terms the Modernist design philosophy elitist and anti-middle-class in its stern moral rejection of the simple pleasures of ornamentation.



This is an interesting thesis, but Brolin fails to support it. First, his historical overview is so rudimentary as to seem almost slapdash. Since he wants to pit Modernism against everything else, Brolin gives us a historical account that sees no differences among the function and aesthetic viewpoints of furniture designers, cathedral builders, metalsmiths, sculptors, and potters. No matter what they were making, or when or where they made it, we are supposed to believe that these craftspeople merely gave ungoverned expression to the invariable human lust for ornament.

One problem is that Brolin does not provide a useful definition of "ornament." Instead, near the end of the book, he dredges up a simplistic one from the dictionary. He therefore does not consider the probability that people's view and uses of ornament might vary from culture to culture, century to century, and artifact to artifact. Tremendously important issues and episodes in the history of aesthetics are skated over or ignored entirely.

For example, the Iconoclastic frenzy of Byzantine Christendom, with its proscription against the worship of images, greatly affected the meaning and use of decoration in the architecture of the Eastern Church. Because builders were not allowed to depict anything recognizable, they instead covered their structures with intricate or-

namentation, which took on religious significance. This influence persists today. Here is a clear case where far from functioning only as "simple human pleasures of the eye," ornaments have had a profound relationship to a specific moral and religious climate. In fact, an interesting parallel might be drawn between Iconoclasm's ban on images and Modernism's so-called ban on ornament.

The author claims that the real reason behind the "death of ornament" in Modern architecture was the inability of the artistic elite to tolerate the taste of the new middle class, whose money began to impose its preferences on buildings and products. Brolin claims that these preferences are the "natural ones" that have existed throughout the ages. However, it is far from clear that the taste of the emergent middle class for heavily ornamented items was anything natural. Mass production, the increasing availability of consumer goods, and the resulting need to advertise them worked to impose a taste from above on consumers. Because they resembled highly ornamented, individually crafted items, mass-produced goods could both satisfy the bourgeois desire to acquire taste and recall a simpler time before the rise of machine culture.

Brolin fails to recognize that it was this sort of cultural duplicity that the Modernist designers were reacting against. To them mass-produced ornamentation was an affordable touch of pseudo-individuality in an era when the meaning of the individual was starting to come into question. In calling for a return to the functional, in decrying the tendency (in satirist Karl Kraus's words) to "turn a chamber pot into an urn," the modernists were responding to a deeply felt crisis of culture.

Thus the book's two separate strands—the narrow polemic against Modernism's design philosophy and the breezy, historical once-over—don't sit well together. *Flight of Fancy* is extensively illustrated, but the captions accompanying the photographs are all too often on the level of a high-school textbook. Considering the large picture/text ratio, the reader is forced to conclude that the material, interesting though it is, would have worked better as a magazine article rather than an expensive book.

THOMAS FRICK is an art critic living in Cambridge, Mass.

Fruits of Research and Threats to its Future

Threats to Universities

Federal actions are "chilling" the relationship between the government and the nation's research universities, says M.I.T. President Paul E. Gray, threatening "a wall of ice" between the two.

"In a decade and a half of changing federal-budget priorities, national economic distress, and—more recently—concern about an alarming budget deficit, too many are too ready to shortchange the basic scientific research upon which America's competitive technological edge depends," President Gray told the American Association for the Advancement of Science (AAAS) last spring.

Gray gave five examples of dangerous federal attitudes and actions:

☐ A steady erosion in federal funds available for grants to students. Especially in graduate-student support, there has been a "sea change," Gray said. Federally supported fellowships, traineeships, and research assistantships in the sciences have dropped 50 percent since 1969.

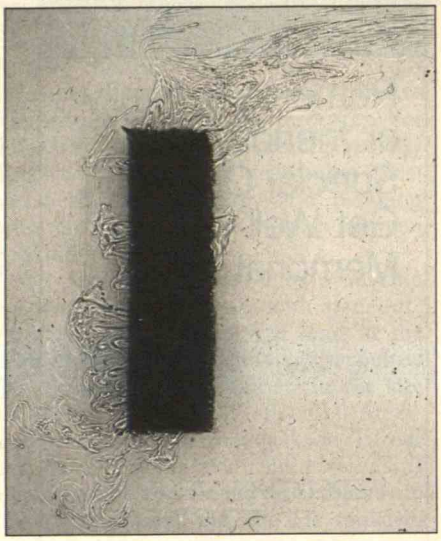
☐ A gradual drift in federal research funding from science toward technology, especially technology related to defense. Two-thirds of the total federal R&D budget now supports military studies, said Gray. He fears this trend will draw talented people away from non-defense research.

☐ Decreasing federal commitments to improve research facilities on U.S. campuses. "Much of our equipment is either obsolete or obsolescent," Gray said, "and these deficiencies are exacting their toll on the university research environment." Funds for facilities fell 90 percent between 1966 and 1981.

☐ Federal efforts to curtail open communication of scientific and technical information in the interests of "national security and competitiveness in the international marketplace." Gray admitted that such interests are "legitimate," but he said that those who propose to censor publications or close laboratories to foreign visitors "underestimate the importance of independence and openness to the scientific process."

☐ Recent efforts by the Reagan administration to reduce federal payments for government-sponsored research. The universities are confronted by "a remarkably unilateral, arbitrary, and mindless [challenge from] the Office of Management and Budget" (OMB) to limit what are called "overhead charges," Gray said.

The horizons of science have never been more challenging, Gray said. "But for their promise to be fulfilled, there must be a renewed commitment to the partnership between government and academe." He called on his AAAS audience to join the battle on the universities' side—"to communicate and to persuade, to become involved in the decision-making processes and in communicating the value of what we do."



Lay a sheet of photographic film, emulsion side up, on the bottom of a flat pan that is three feet or more beneath a strobe lamp. Cover the film with a quarter inch of water, and set a cube of sugar in the water. Then wait 10 seconds and flash the strobe. Harold E. Edgerton, the world-famous inventor of strobe photography who devised this simple procedure, was surprised to find impurities whose origin remains to be traced.

Drugs in Plastic

When you take a pill, the level of medicine in your body rises suddenly—and then gradually falls off until you take another. That's well enough for many medications, but a constant level would often be better—in the case of diabetics receiving insulin, for example.

Solving that problem through controlled-release technologies is the specialty of Robert S. Langer in the Department of Applied Biological Sciences at M.I.T. In a paper for the American Chemical Society last spring, he reported two new controlled-release techniques based on putting drugs into polymer implants.

Drugs in biodegradable implants are gradually released as the polymer dissolves. If non-biodegradable polymers are used, the medicine simply seeps out gradually. In both cases, the rate of release can be changed by exposing the polymer to ultrasound.

Adding an enzyme to the drug-carrying polymer implant may provide automatic adjustment of the rate of release. For example, Langer proposes that a non-biodegradable polymer might carry insulin and the enzyme glucose oxidase. If the polymer were exposed to external glucose, the enzyme would produce acid inside the polymer, which would cause increased release of insulin.

Though these concepts are now being tested in Langer's laboratory, he warns that they're "years away from everyday use."

Black Holes and Bent Light

Two discoveries by M.I.T. astronomers made news last spring:

☐ A dark, massive object that occasionally bursts into x-ray brilliance was identified as a "probable" black hole. The object is bound gravitationally to a faint red star in the constellation Monoceros. If confirmed, as a black hole, it would be the third found so far, said discoverers Jeffrey E. McClintock of the M.I.T. Physics Department and Ronald A. Remillard of the Center for Space Research.

☐ Physicist Bernard F. Burke and two graduate students, Jacqueline N. Hewitt and Glen I. Langston, share with astronomers at Caltech and the Institute for Advanced Study discovery of an unexpectedly large gravitational lens—400 times more massive than any previously found. They explain that a gravitational lens results when light from a distant object such as a quasar passes near a strong gravitational field. The light bends around the object that creates the gravitational field and reaches the earth-bound observer from two or more slightly different directions. Thus the observer seems to see several identical objects in different locations. But in this case a mystery remains, since the object causing the gravitational field has yet to be observed.

PHOTO: HAROLD E. EDGERTON

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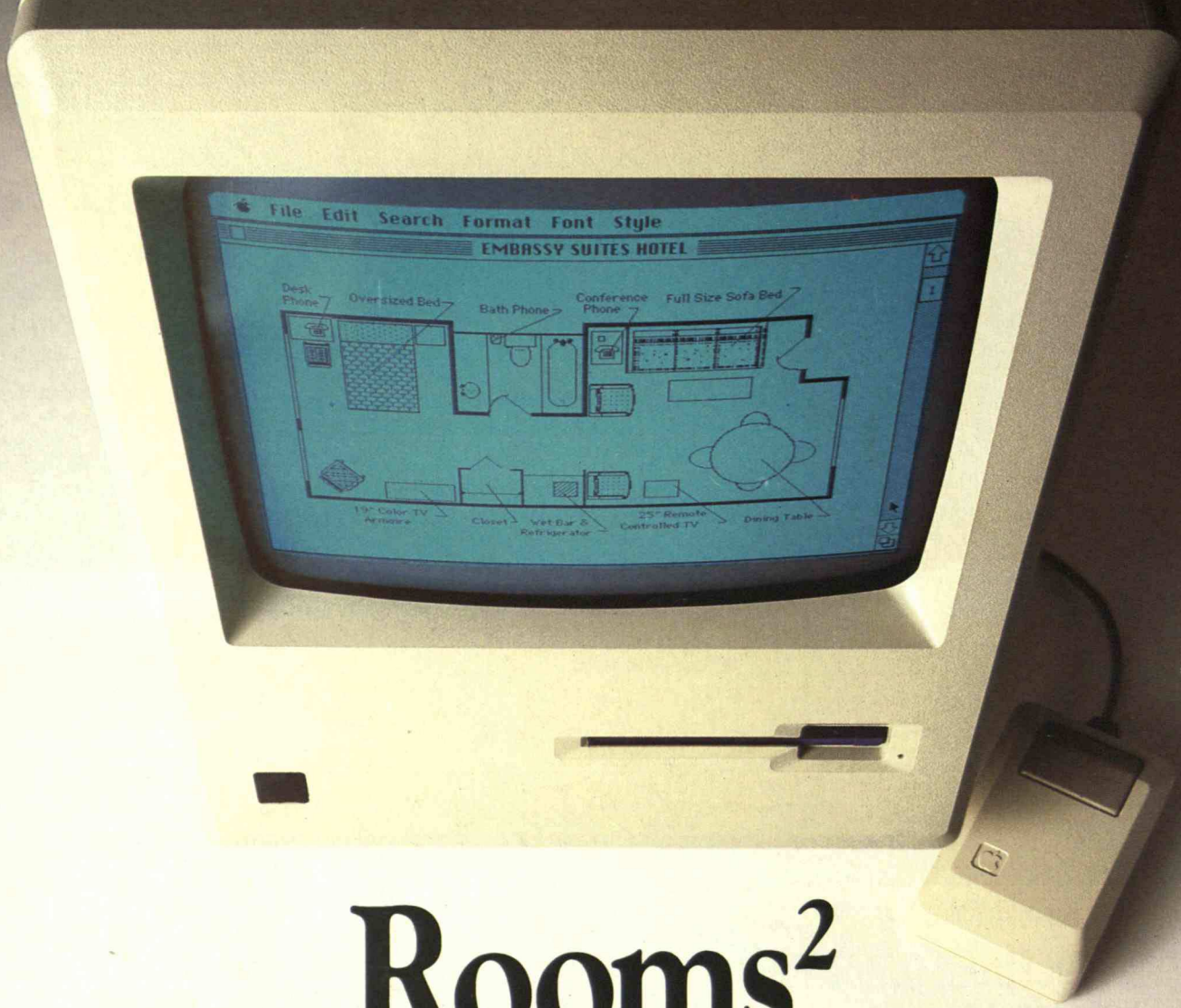

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